Plastic Pipe Collection for Recovery in Finland

Rasmus Pinomaa

Department of Energy and Materials Technology

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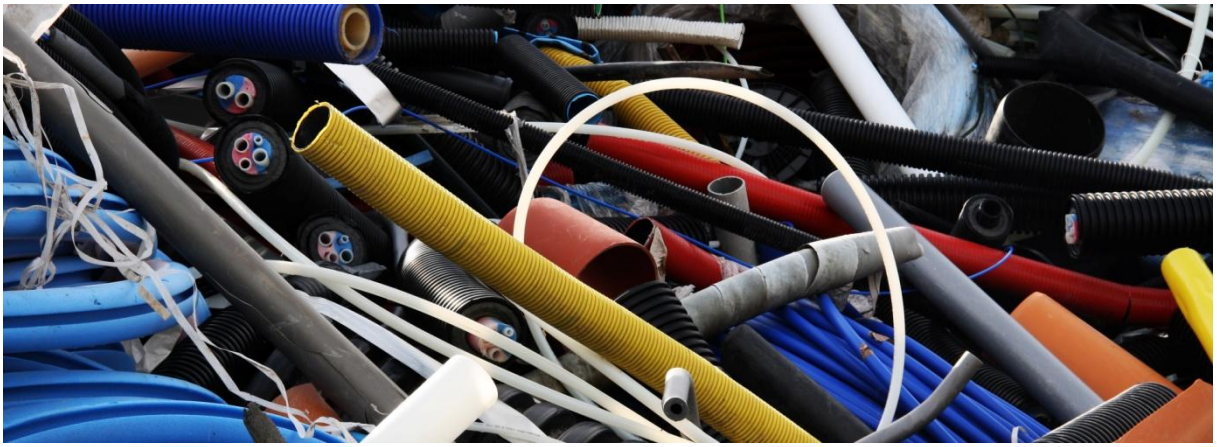

MUOVITEOLLISUUS RY
Finnish Plastics Industries Federation

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Author:	Rasmus Pinomaa
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Abstract:

The Pipe Group in Muoviteollisuus Ry has been running a voluntary recycling system for plastic pipe waste in Finland since year 1999. The contract for this system is expiring in the end of year 2011. A new contractor needed to be found because the existing system has not worked as expected, is expensive and is impractical. This study researches alternative ways of taking care of the plastic pipe recycling system in Finland and also offers solutions and suggestions on how to do it. To better understand the problems behind recycling plastic pipes, a questionnaire, several interviews and field studies were made. The studies showed that there are many companies in the Finnish recycling business and several of them would be interested in recycling plastic pipes. These companies were compared in many ways for example cost, logistics and geographical location which lead to a couple of suggestions. These suggestions were used as a guideline for choosing a new partner for the plastic pipe collection for recovery continuing with a new contract in 2012.

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Sammandrag:

Rörgruppen i Muoviteollisuus Ry har haft ett frivilligt återvinningssystem för plaströrs avfall i Finland sedan år 1999. Kontraktet för detta system kommer at gå ut i slutet av år 2011. En ny samarbetspartner måste sökas för att det nuvarande systemet inte har fungerat som väntat, det har varit dyrt och opraktiskt. I denna avhandling har man forskat vilka alternativa sätt som kunde finnas för att fortsätta återvinningen av plaströr i Finland, forskningen bjuder också på lösningar och förslag på hur detta kunde göras. En förfrågan, flera intervjuer och fältstudier har gjorts för att bättre förstå problematiken bakom plaströrs återvinning. Forskningen visar att det finns många aktörer på den Finska återvinnings marknaden och många av dem skulle vara intresserade av att återvinna plaströr. Dessa aktörer har jämförts sinsemellan på olika sätt, bland annat med avseende på logistik, kostnader och företagens geografiska lägen. Detta ledde till några helt nya förslag. Förslagen användes som ett riktgivande underlag för att välja en ny samarbetspartner för plaströrs återvinningen som fortsätter med ett nytt kontrakt i början av år 2012.

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Tiivistelmä:

Muoviteollisuus Ry putkijaosto on pyörittänyt muoviputkijätteelle suunnattua vapaaehtoista muoviputkien kierrätysjärjestelmää Suomessa vuodesta 1999 lähtien. Sopimus tälle järjestelmälle on voimassa vuoteen 2011 loppuun asti. Uuden toimijan löytäminen on välttämätöntä sillä nykyinen järjestelmä ei ole toiminut odotetulla tavalla, on kallis ja on epäkäytännöllinen. Tämä selvitystyö tutkii vaihtoehtoisia tapoja hoitaa muoviputkien kierrätystä Suomessa ja tarjoaa myös ratkaisuja ja ehdotuksia siihen kuinka asiaa voitaisiin lähteä viemään eteenpäin. Jotta muoviputkien keräyksen ja kierrätyksen problematiikka olisi helpommin ymmärrettävissä on selvitystyössä tehty kysely, lukuisia haastatteluja ja kenttätutkimusta. Tutkimukset osoittivat että Suomessa on lukuisia toimijoita kierrätysalalla ja moni niistä olisi kiinnostunut hoitamaan muoviputkien kierrätystä. Näitä toimijoita vertailtiin muun muassa kustannusten, logistiikan ja maantieteellisen sijainnin mukaan. Nämä vertailut johtivat muutamaan ehdotukseen. Ehdotuksia käytettiin ohjenuorana uutta toimijaa valittaessa muoviputkien keräykseen ja kierrätykseen joka jatkuu 2012 eteenpäin.

Avainsanat:	muoviteollisuus, kierrätys, muovi, putket, keräys, suomi
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ABBREVIATIONS

PE	Polyethylene
PE-LD	Low-density polyethylene
PE-HD	High-density polyethylene
PE-RT	Polyethylene with raised temperature resistance
PE-HD-UHMW	High-density ultra high molecular weight polyethylene
PP	Polypropylene
PVC	Polyvinyl chloride
PEX	Cross-linked polyethylene
PET	Polyethylene terephthalate
PS	Polystyrene
EPS	Expanded polystyrene
ABS	Acrylonitrile butadiene styrene
ASA	Acrylonitrile styrene acrylate
SAN	Styrene acrylonitrile
PMMA	Polymethyl metacrylate
PA	Polyamide
PUR	Polyurethane
HPAC	Heating, piping, airconditioning
HVAC	Heating, ventilation, airconditioning
SUM	Suomen Uusiomuovi Oy

L&T	Lassila & Tikanoja
WEEE	Waste electrical and electronics equipment
ELV	End-of-Life vehicles
ASR	Auto shredder residue
EFW	Energy from waste
T_m	Melting temperature
E_t	Tensile modulus of elasticity
NPG	Nordiska plaströrsgruppen
BIS	Buizen inzamel systeem
PSW	Plastic solid waste
KRV	Kunststoffrohrverband
HSY	Helsingin seudun ympäristöpalvelut

1 INTRODUCTION

It has been concluded in the last decade that the human population can not continue abusing planet earth like it has for the last couple of hundred years. Especially the industrial and technological revolutions have increased understanding and made people realize that there are limited resources on our planet. Yet still goods are being produced more than ever, more waste is piling up on landfills and the surroundings are being strategically poisoned from the ground to the upper levels of the atmosphere. The natural resources on planet earth are finite, that is a fact, and to be able to feed the need of goods and technological necessities new solutions need to be found before all the resources are gone. This situation has woken people up and made people realize how important recycling and waste management can be.

Plastics are very suitable to be recovered and used again in new purposes. In Finland there is no separate recycling for household plastic [1] but in the industry plastics are recycled. In many cases the recycled plastic becomes incinerated as energy recovery, which is a very suitable way to recover plastic because of its high energy content, but more and more plastics are recycled into new raw material. Plastics are hard to recycle, mostly because it is challenging to create constant homogeneous waste streams. Other dilemmas are the separation of different plastic, the fluctuating market prices for plastics and the demand for recycled plastic raw material. In Finland companies are getting more aware of recycling and nowadays many companies have an internal recycling system where they aim at using most of their own waste. More and more initiatives are also taken by the industry to start recycling programs because of modern trends like producer responsibilities and the image of companies.

The plastic pipe industry and the Pipe Group in Finnish Plastics Industries Federation have been recycling plastic pipes in Finland for almost twelve years now. The pipe industry is a smaller contributor to plastic waste than many other industries, approximately 10% of the annual plastic waste [44], but still there are annually hundreds of tons of plastic pipe waste generated. Recovering materials is a modern trend but also a hugely important business nowadays, and for our continued survival on this planet, a necessity.

1.1 The situation now

In 1999 the Pipe Group of the Finnish Plastics Industries Federation (Muoviteollisuus Ry) started a cooperation with Säkkiväline (nowadays known as Lassila & Tikanoja) and SUM Oy (Suomen Uusiomuovi Oy) with the aim to start collecting plastic pipe waste so that a lot of that waste would be recycled. The main goal for this cooperation was to reuse as much of the waste plastic pipes as possible, either by recycling it to recycled raw material or using it as energy recovery waste so that it could be incinerated to get energy out of it. This was a non-profit cooperation with the main objective to create an end of sustainable development for the plastic pipe lifecycle. [2]

In practice it was agreed that there would be containers placed on wholesalers (Ahlsell Oy, Onninen Oy and LVI-Dahl Oy) yards and Lassila & Tikanoja would gather the waste plastics and further process it. The Pipe Group consisting of Oy KWH Pipe Ab, Uponor Suomi Oy and Pipelife Finland Oy would finance the collecting of the plastic pipe waste. There were all in all 12 containers that would be used for this purpose, 11 of them in actual use and one as a reserve container. The estimation at that time was that there would be approximately 100 tons of plastic pipe waste annually consisting of mainly polyethylene (PE), polypropylene (PP), polyvinyl chloride (PVC) and cross-linked polyethylene (PEX) pipes. The wholesalers would function as gathering points and plastic pipe waste could be dumped at these places from for example wholesalers, construction yards and water management facilities. [2]

In the beginning all plastic pipe waste was taken to Muoviportti Oy in Harviala to be sorted, washed and crushed. In 2003 the treatment of plastic pipe waste was moved to L&T recycling facility in Kerava and washing of the waste was terminated. In 2007 it was agreed on that L&T would also accept plastic pipe waste in Oulu, Jyväskylä and Turku recycling facilities. These facilities could however only process the plastic as energy recovery and no recycling to raw material could be done here. Mainly PE and PVC has been converted into raw material and shipped back to factories but today PVC is no more recycled to raw material. [2]

There have been many problems with the current system of recycling plastic pipe waste. A big amount of the waste is dumped at landfills, the wholesalers do not know well enough how to sort the different plastic pipes which has lead to misuse of the containers, the raw material markets are unstable so the need for recycled raw material can not be foreseen and the annual amount of plastic pipe waste has been lower than expected (around 30 tons annually). All these problems, the misuse of the recycling system and the low amounts of waste has made different parties in this cooperation unsatisfied with the situation and a need for a better and functioning system has been growing under the surface. [2]

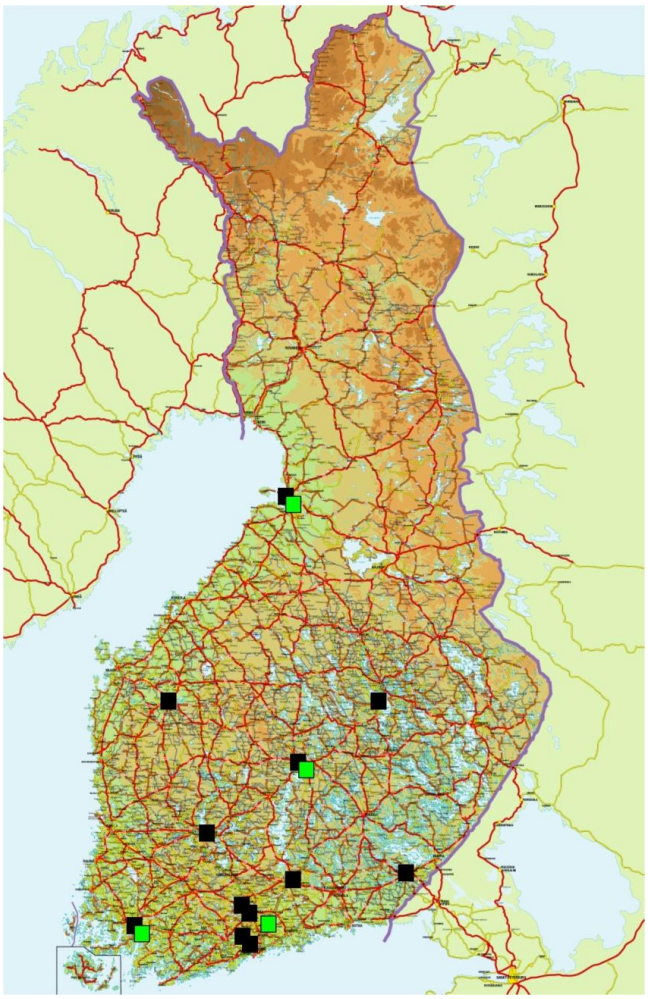


Figure 1 Map of Finland with current plastic pipe recycling system in Finland

Today the plastic pipe waste is collected in 12 different locations and can be taken to 4 different recycling facilities, this is seen in figure 1. On the map a black square symbo-

lizes a place where plastic pipe waste is collected and a green square stands for a place where the waste is recycled. All companies that were mentioned before are still involved in the recycling cooperation but the contract with L&T will end 31.12.2011 and this is why a new solution needs to be found. [2]

1.2 Aims and objectives

The Pipe Group of Muoviteollisuus Ry has the aim of finding a new way of recycling plastic pipe waste since the companies cooperating with the plastic pipe recycling are unhappy with the situation now. The most important questions are, how can the recycling of plastic pipes be made in Finland so that all parties are satisfied and the system works well and serves its cause? These problems will be tackled by interviewing different parts in this cooperation, by doing field studies to the locations where the plastic pipes are collected and recycled and by researching existing systems in other countries and existing local systems around Finland. The possibility of incorporating the plastic pipe collecting into another existing waste management system in Finland will also be investigated. The cost effectiveness of different systems will be compared. To understand the plastic pipe recycling better and the aims of this research some problems in the current system needs to be overseen.

The most important thing in plastics pipe recycling is that the material is recycled by the terms and conditions that the companies that created the system has stated. One of the biggest issues with the current system is that the containers are not serving their cause because they are misused. Not only misused by the wholesalers on their yards but also by the company that is responsible for them, L&T. For example, there are stickers on the containers saying “plastic waste” (muovijäte) though the containers are only for collecting plastic pipe waste, not plastic waste in general. This has lead to people throwing all kinds of plastics in these containers and in the end it has not been possible to recycle these as planned and some container waste has ended up on landfills. This leads to the problem that the companies that has created this system will have to pay a double fee, first the logistics to move the waste plastic from one place to another and then the waste management cost to the respective landfill. So other solutions and a better functioning system will be researched.

Another aspect to this problem is the logistics in plastic pipe recycling. Finland is a sparsely populated country and the distances are quite big. So the ideal solution for environmentally friendly recycling would be to recycle locally everything. The recycling facilities are however located close to bigger population centrals so the waste has to be moved to these facilities and this is why completely local recycling is not possible. When moving recycled material from one place to another, it is very important that the biggest possible amount of material is moved at the same time. This means that it is more profitable if there is less free room (air gaps) in the containers. Plastic pipe waste is usually recycled in the form of long pipes (up to 6m long) and these are placed in the containers. This means that there will be a lot of air gaps in between the pipes. If the pipes would be cut into smaller pieces at the location where they are gathered there would be much more waste material fitting into the containers and the containers would need to be emptied lesser times which would save kilometer costs. So not only the gathering needs to be overseen, the actual moving of the pipes is a crucial and the most expensive part of plastic pipe recycling.

Material wise there are also problems. Since plastic pipe waste mainly consists of PE, PP, PEX and PVC no other plastics can be tolerated in the containers. Just a few foreign objects cause much more work when the containers are transported to recycling facilities and sorted. This is particularly important if the material is supposed to be recycled into new raw material. If it is recycled into energy recovery then the most important thing is that the container contains only plastics but this is not the objective of the plastic pipe waste recycling in Finland. There is another recycling system for energy recovery that is turned into fuel at recycling facilities and later used as fuel for example for the forest industry in Finland. Another important thing is that there can not be any contamination in the waste plastic material. This means that the plastic pipes that are recycled are mainly waste from newly produced pipes that are shipped to wholesalers and other recipients and damaged on the way or damaged when handled at the recipient. Water pipes are also good for recycling but many other pipes are handled as problem waste because of heavy contamination and because washing the plastic pipes are very expensive.

So the aims and objectives of this research are:

1. To find out what other existing systems there are that could collect and recycle plastic pipes and could the plastic pipe collecting join one of those systems
2. To find out would it be more cost-effective to use another waste management system than the current one to collect and recycle plastic pipes
3. To find out would it be worth developing the existing system, and in this case, how to bind the parties in the system to use it as it should be used, in a correct and effective way

The Environmental Group, a sub-chapter of the Pipe Group of Muoviteollisuus Ry, is supposed to have results from this research in the end of October 2011. At this point there should be 2-4 suggestions on how to continue with plastic pipe collecting and recycling in Finland.

2 LITERATURE REVIEW

2.1 Recycling plastics

Collecting and recycling plastics is a complex and multi phased process. There are several different outcomes for the recycled plastic and hundreds of different actors in the recycling business.

It is crucial to understand the system of recycling plastics before trying to come up with solutions. In general the plastic waste flow can be divided into two major areas, post-consumer waste and production and processing waste. The post consumer waste is all plastic products that have left the factory and are intended for further use in the society, for example “waste streams from private households and commerce (plastics waste collected by or on behalf of municipalities of households and commerce as well as generated by economic activities such as manufacturing industry, construction, agriculture)”. Production and processing waste on the other hand is “waste treated outside the production and processing enterprises”. This research will concentrate on post consumer waste and in particular from commerce. The amount of post consumer plastic waste is considerably higher than the amount of production and processing waste plastics. [3]

The post consumer waste is divided into two different waste streams, household waste and commercial waste. Household waste consists of the following waste streams [3]

- Residual household waste, “residential waste collected by or behalf of municipalities (excluding all waste fractions, which are collected separately)
- Bulky household waste, “collected by or for local authorities” also excluding other waste fraction separately collected. Bulky waste needs special considerations for its management
- Sales packaging collected, packaging collected by integrated systems with their own financial system

- Separate collection by municipalities, “separate collection of waste fractions for recovery operations from households and other by or on behalf of municipalities”.
- WEEE waste collection, waste from electrical and electronic equipment from households and all kinds of commercial and industrial activities.

Commercial waste on the other hand consist of the following waste streams [3]

- Municipal waste generated by commercial activities, waste similar to household waste created by commerce, trade, small businesses, institutions and municipal service
- Commercial and industrial waste, “collected, sorted, treated and disposed of by private waste management enterprises”
- Commercial packaging waste, waste generated by the packaging of products in the industry, treated by private enterprises and national recycling systems
- ELV including ASR, from apart taken vehicles (End-of-Life Vehicles) and Auto Shredder Residue
- Other recycling systems, other national collecting and recycling systems for specialized areas of recycling, for example pipes and PVC waste

2.1.1 End uses

To better understand what happens with the waste it is good to understand the end uses and recycling goals. From Figure 2 it can be seen that after the waste is collected there are two possibilities where the plastic waste can end up, either it is recycled in some way or it ends up on a landfill unused. The best option always is to get rid of the material in some way, this way it will not pollute the surroundings or occupy areas of land that could be used for other purposes. To get rid of the plastic waste or to use it again the following methods are applied [3]

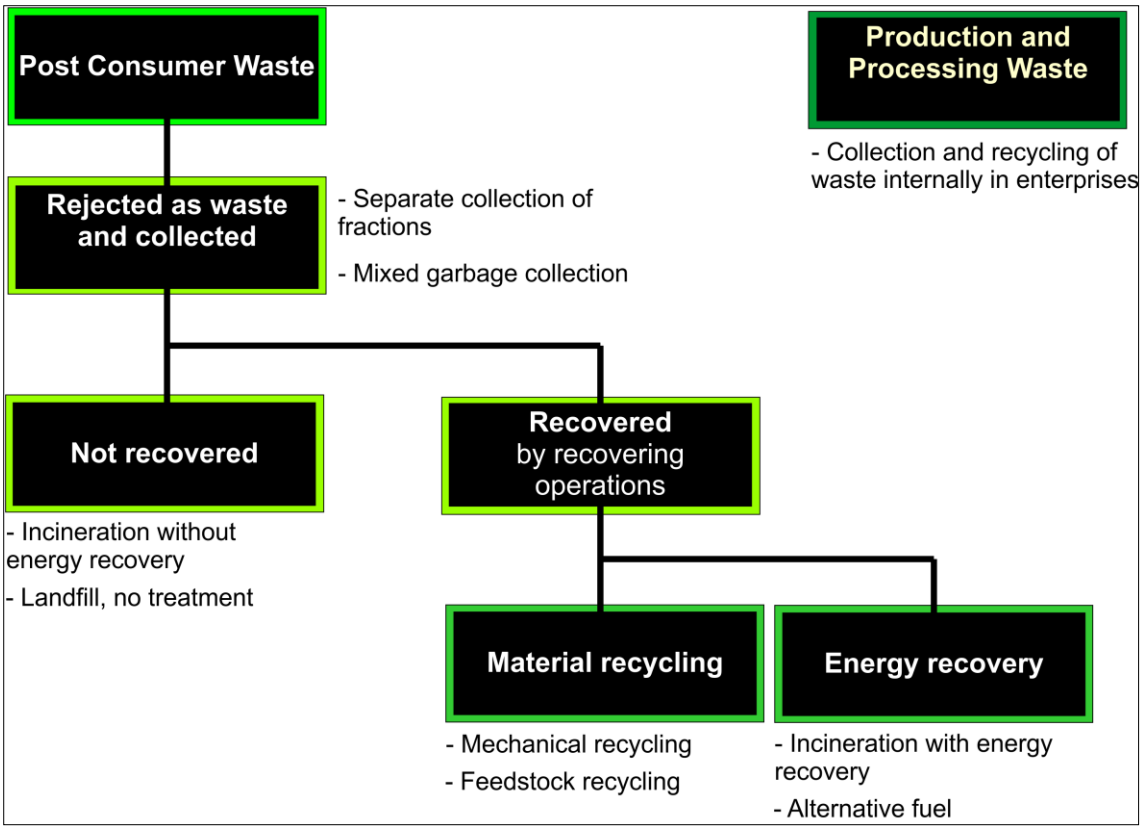


Figure 2 How the recycling of plastics works [3]

- Incineration without energy recovery, the waste is burned and in this way reduced in quantity without benefitting anything from the actual material. Requires energy and does not have any significant output
- Energy recovery, "includes both direct combustion at efficient waste incinerators" and "high grade energy recovery at industrial facilities" [3]. A way of burning the plastic waste so that the bonding energy of plastic is recovered and can be used to produce energy and/or heat for households or industrial production facilities. Main objective is to replace fossil fuels
- Mechanical recycling, this is suitable if the plastic waste material is separately collected, somewhat clean and homogeneous. The amount of plastic waste that can be mechanically recycled is limited because the material has to be of a high quality (close to post industrial waste)
- Feedstock recycling, "defined as a change in the chemical structure of the material, where the resulting chemicals are used for another purpose than producing

the original material". "Mixed plastic waste is suitable for feedstock recycling techniques"

These different techniques are often put in an order according to priorities. The first thing to consider is of course to re-extrude the waste plastic at the location of the factory (production and processing waste) but the following priorities mainly concern post-consumer waste. Priority number one is material recycling, priority number two is energy recovery and priority number three is no recovery at all. So when considering plastic recycling, the first priority for every process is always to either by mechanical recycling, or feedstock recycling, use the material again to a meaningful purpose. If this is not possible, not cost-effective or not beneficial of some other reason, priority number two comes into question and the materials energy is recovered with incineration. If none of these methods make sense, then the last option is to take the waste to a landfill or just burn it without gaining anything from it. [4]

There has been a discussion about if these methods are truly environmentally friendly and it has been stated in research that in "environmental impact categories like energy use, including global warming potential, acidification potential, eutrophication potential, abiotic resource depletion potential and residual solid waste production", mechanical recycling is the environmentally preferred option to recycle plastics. It has also been shown that the low ratio of recycled raw material blended with virgin raw material used in production processes and the amount of contamination in much plastic waste makes the incineration with energy recovery a more environmentally friendly option. [5]

2.1.2 Type of plastic

The plastic recycling is somewhat difficult because there is such a big amount of different materials that can be recycled. This is why the SPI identification system has been introduced along with some other identification methods. The SPI system is developed by the packaging industry and it consists of "triangular-shaped recycling arrows and a number between 1 and 7. Often this is accompanied by the abbreviated name of the plastic", the signs of the SPI system are in figure 3. There are many other ways also to recognize which plastic is in question, for example observation tests, burning tests and

water tests. In water tests it is easy to separate basic polyolefins and foams from other plastic since these float and most other plastics sink. Some plastic burn with a certain color flame and are thus easily recognized. With the earlier mentioned tests and by observation an "engineer is often able to identify most plastics". To find out the type of plastic is nowadays made in many recycling companies by plastic recognition systems with optical cameras and different sensors. [6]

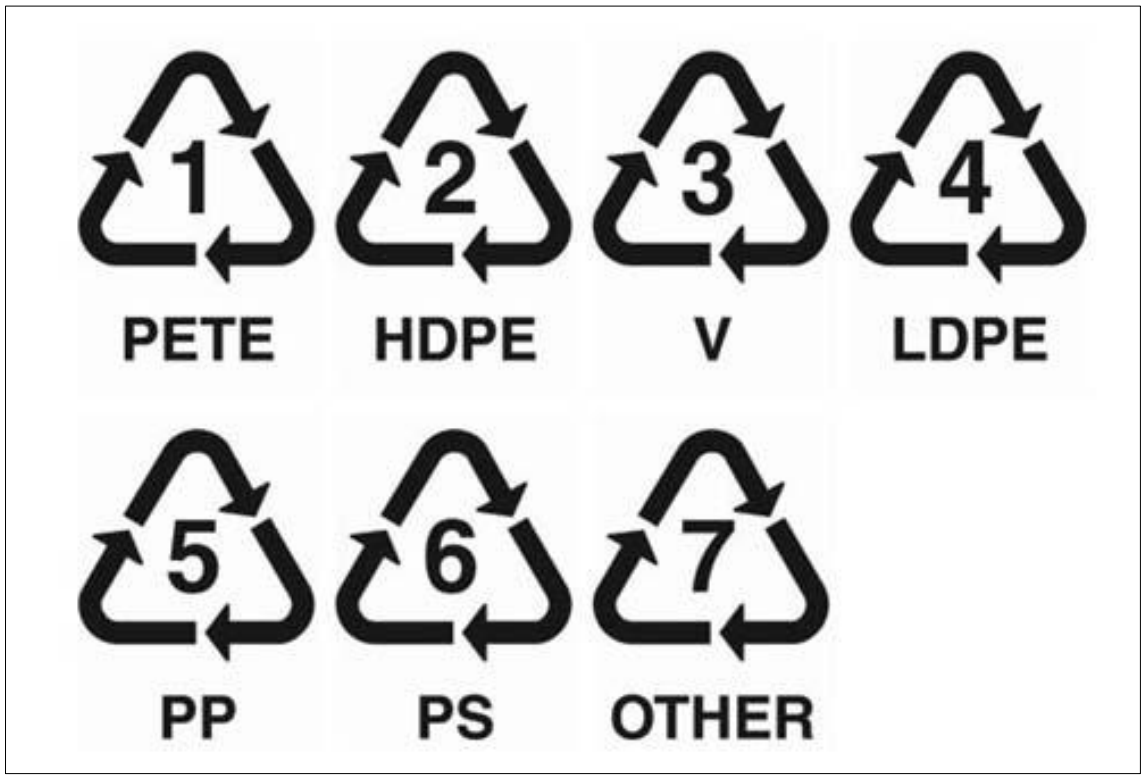


Figure 3 The SPI identification symbols for plastics packaging recycling [50]

2.2 **Recycling in Finland**

The image that the average consumer has of plastics is not very flattering. People do not think that the plastic waste management is well organized. The most common opinion nowadays that people have is that plastics pollute our environments, before 1991 the first thing that came to mind when plastics was mentioned was practicality for most of the people. This shows that attitudes have changed and that something needs to be done to plastic waste, not only because of it polluting our environments but also for the plastic materials to get a better reputation. [7]

In Finland about 200 000 tons [3] of plastic waste is generated every year. More than half of this is packaging material and the rest is plastic products and parts that have come to the end of their lifecycle. The plastic waste consists in general of several chemically different plastics and often these are a part of other waste and scrap. Different plastics are recycled in different ways and the most suitable recycling path is always individual and dependent on the plastic properties and use. Approximately 30 000 tons of plastics are recycled in Finland annually and used again for new purposes, depending on the year, 40 000 – 60 000 tons are recycled as energy recovery waste every year, so close to 115 000 tons of plastics end up on landfills every year. As a percentage of mass, plastics are 5% of the annual waste, in volume percentage the amount of plastics is a little bit higher. Lately recycling of plastics has become more and more interesting because of environmental awareness, rising raw material prices and because of waste disposal costs. A completely new area of business has been born around recycling plastics. [7]

No waste legislation directly regulates the use of plastics. There are however legislative factors that support a sustainable use of plastics and guides waste plastics to an environmentally friendly end use. Many of the companies in the plastic business have something to do with environmental permits. If you need to apply for an environmental permit you also need to clarify how wastes generated by the company are handled. A waste managing contract can be made with any municipal or private company and it is quite free to choose where your waste ends up and who further processes it. Municipal waste management companies mainly treat household waste and in many cases also waste from the industry, they are however not obliged to handle the industrial waste. If a contract is made with a private company it is important to know that this company has an environmental permit that proves they have a license to deal with waste. [7]

The plastic waste generated in the industry is a double loss, the waste is raw material that has been bought and not used in its end purpose. If the waste plastic is already processed then also the energy and working hours used in processing are lost. On top of this there is a waste handling fee that in Finland is 100 €/ton for normal waste. Logistics and freight can add a couple of hundred euro more to the final cost, this is why it is very important to minimize waste volumes. Regardless of all the efforts to minimize waste,

2-15% of purchased plastics (depending on the company) will never end up in the final product. This has led to material effectiveness inside companies, the waste is usually used in another product where the material requirements are not so high or then it is granulated again so that it can be reused. Other companies have specialized in using this waste plastic as a raw material in their own processes and they get it for a nominal price. In this way both companies benefit from the waste material. In Finland there is close to ten companies that process recycled plastics by cleaning it and modifying it to reusable material. Some of these companies also produce their own products from recycled raw material. The recycled plastic industry in Finland is able to process about 30 000 tons of recycled plastic annually. Some waste plastics can not be processed further in Finland but in other parts of the world they can be used and for example the Asian fiber industry uses recycled plastics from Europe as a raw material. [7]

Incineration facilities have not been built in Finland for decades, however bigger companies have their own stoves that have been able to burn energy recovery waste for a longer time already. Now the trend is changing and right now close to ten incineration facilities are planned to be built in the upcoming 10-15 years. Plastic waste can easily be burned in these facilities and gives an added value to the waste energy level and thus more heat that equals more energy. The burning has to be done in high enough temperatures and in this case the plastic breaks down into carbon dioxide and water. PVC is an exception in the burning of plastics, it releases in high temperatures dioxins and breaks into hydrochloric acid which makes it much harder to incinerate and highly corrosive. [7]

2.2.1 Statistics from Finnish plastic recycling

From table 1 it can be seen that in 2009 in Finland the total generation of plastic waste has been 199 kilotons from which the biggest part is packaging waste (55,4%) and other waste (17%). All other fields contribute with around 5%. The recovery figures show that all in all 84 kilotons of the plastic waste has somehow been used for recovery which is around 42% of the total plastic waste volume. Approximately 31 kilotons have been recycled by mechanical recycling and 53 kilotons has gone to energy recovery. 115 kilotons of plastic waste has ended up as disposal (58% of total plastic waste volume) and

close to all of this is taken to landfills. Here it is noticeable too that in Finland no incineration without EFW (energy from waste) is done and feedstock recycling is also very unpopular. With these statistics in mind Finland gets a recycling rate of 16% (mechanical and feedstock recycling), a recovery rate of 41% and disposal rate of 59% (the plastic that ends up on landfills).

Table 2 Plastic waste and recycling in Finland [3]

Finland 2009 Applications	Total Generation			Recovery in kt				Disposal in kt		
	kt	kg/ cap.	%	Total	Mechanical Recycling	Feedstock Recycling	Energy Recovery	Total	Landfill	Incineration without efw
Packaging	110	21	55,4%	67	26	0	41	43	43	0
Building/Construction	12	2	5,9%	4	2	0	2	8	8	0
Automotive	8	2	4,2%	2	1	0	2	6	6	0
Electrical/ Electronics (WEEE)	14	3	7,0%	3	1	0	2	11	11	0
House wares, Leisure, Sports etc.	11	2	5,4%	2	0	0	2	8	8	0
Agriculture	10	2	5,1%	1	1	0	0	9	9	0
Others (Furniture etc.)	34	6	17,0%	4	0	0	4	30	30	0
Total	199	37	100%	84	31	0	53	115	114	0
				42%	16%	0%	27%	58%	58%	0%

Table 1 Recycling in Finland, comparison with year 2009 and 2008 [3]

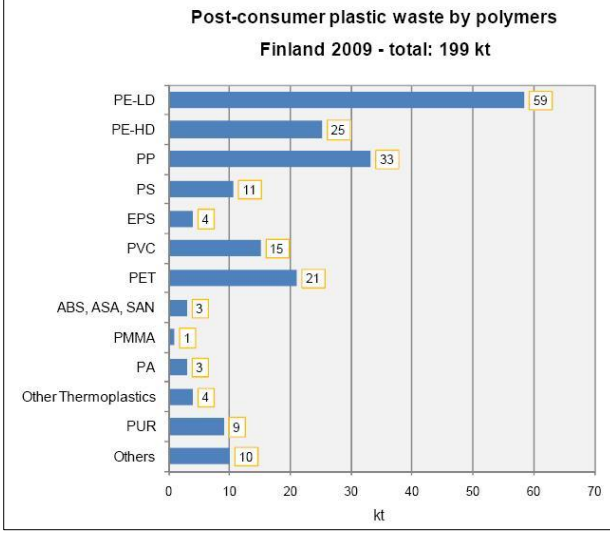
Finland 2009 Applications	Generation		Recovery							Disposal	
	in kt	△ % 2008	Total	△ % 2008	Mechanical Recycling	△ % 2008	Feed stock Recycling	Total Energy Recovery	△ % 2008	Total	△ % 2008
Packaging	110	-4,3%	67	32,8%	26,2	-1,5%	0	41	70,8%	43	-33,5%
Building/Construction	12	-10%	4	0%	2,0	0%	0	2	0%	8	-14%
Automotive	8	-5%	2	31%	0,6	0%	0	2	50%	6	-13%
Electrical/ Electronics (WEEE)	14	-7%	3	-3%	1,1	-8%	0	2	0%	11	-7%
House wares, Leisure, Sports etc.	11	-6%	2	0%	0,0	0%	0	2	0%	8	-8%
Agriculture	10	-2%	1	0%	1,3	0%	0	0	0%	9	-2%
Others (Furniture etc.)	34	-4%	4	0%	0,0	0%	0	4	0%	30	-4%
Total	199	-5%	84	25%	31	-2%	0	53	54%	115	-19%

In table 2 there is a comparison between recycling in Finland during year 2009 and 2008. No bigger changes can be seen between the two years except for the energy recovery part that was affected positively by an incineration plant that was built in Riihimäki and had its first fully operational year in 2009. This of course also had a huge impact on the amount of plastic waste ending up on landfills in Finland (-19% in disposed plastic waste). In 2009 the amount of plastic waste was a little bit lower than in

2008. Other remarks that are made about the Finnish plastic waste statistics are that the Finnish plastic pipe waste collecting only collects small amounts of pipes (less than 50 tons) and that in the future the Finnish waste law will probably be changed (by 2012) so that for every 500 citizens there should be collecting bins for glass, paper, plastics and aluminum. The aim of the national waste plan in Finland is that by 2016 a maximum of between 460 kilotons and 500 kilotons of municipal waste would end up on landfills and that in 2016 only 30-40 landfills would be needed (in comparison to 10 years ago 100 landfills and today around 50 landfills [7]).

To understand further how the plastic waste is generated in Finland and what it consists of, a couple of more tables describe this even better.

Table 3 The amount (both in volumes and percentages) of different plastics recycled in Finland [3]



Post-consumer plastic waste by polymers - Finland 2009	
Polymer types	in%
PE-LD	29,5%
PE-HD	12,7%
PP	16,8%
PS	5,4%
EPS	2,0%
PVC	7,6%
PET	10,6%
ABS, ASA, SAN	1,5%
PMMA	0,5%
PA	1,5%
Other Thermoplastics	2,0%
PUR	4,6%
Others	5,1%
Total	**100%**

Table 3 shows how much of different materials end up being recycled in Finland. Different sorts of PE, PP and PET are the most common ones. Table 4 shows where the plastic waste comes from and how much of each plastic waste stream ends up in recovery and how much of it ends up in disposal, in other words on a landfill. From this it can be seen that in 2009 different household wastes, municipal waste generated by commercial activities and End-of-Life vehicle wastes were the ones that mostly ended up on landfills. Almost all of the collected packaging waste in Finland ended up as recovery.

Table 4 Where plastic waste come from and how much is recovery or disposal [3]

Finland 2009 Plastic Waste Streams	Generation of Plastic Waste					
	Total		Recovery and Disposal in kt			
	kt	kg/cap.	Recovery	%	Disposal	%
Residual household waste	93	17,5	25	26%	69	74%
Bulky household waste	14	2,7	2	14%	12	86%
Separate collection by municipalities (non-packaging)	0	0,0	0	0%	0	0%
Sales packaging waste collected	9	1,7	9	100%	0	0%
WEEE waste collection	10	2,0	3	25%	8	75%
Municipal waste generated by commercial activities	31	5,8	15	49%	16	51%
Commercial & Industrial Waste	13	2,5	9	67%	4	33%
Commercial packaging waste collected	17	3,2	17	100%	0	0%
ELV incl. Auto-Shredder Residue	7	1,3	2	23%	6	77%
Other recycling systems*	3	0,6	3	100%	0	0%
Total post-consumer plastic waste	**199**	**37,3**	**84**	**42%**	**115**	**58%**

If table 1 and table 4 are compared it can be seen that for example all packaging waste does not come from only commercial packaging waste and collected sales packaging. These two are in total 17 kilotons plus 9 kilotons which equals 26 kilotons and from table one it is apparent that packaging waste is collected 110 kilotons every year. From commercial and sales packaging 100% is recovered but from packaging in general only 61% is recovered. So it seems that most of the plastic packaging that ends up on landfills comes from household waste streams. Considering the plastic pipe waste it is noticeable that most of the waste is categorized as building and construction waste and other waste. Waste streams that handle plastic pipes amongst other waste are “commercial and industrial waste” and “other recycling systems” and these contribute in total to 16 kilotons (13+3) of waste from which 12 kilotons is recovered and 4 kilotons ends up on landfills. From “building and construction waste” and “other wastes” only 8 kilotons all in all are recovered and these are not only pipe waste. So if this is compared to the amount of plastic pipes produced every year which is approximately 70 kilotons [44], and according to evaluations in average 500-1000 tons of the pipes never end up in the final use [43], then an estimation can be made that approximately an eighth of the “building and construction waste” and “other wastes” are plastic pipes.

2.2.2 Companies involved

As in many other countries, in Finland there are both private companies that take care of waste and the municipal waste treatment. In plastic recycling more and more of the plastic waste is treated by private enterprises that further process it and sell it as recycled raw material or as alternative fuel. Municipalities and private companies also collaborate in collecting the waste. For municipalities, outsourcing of the waste treatment has become more on more popular.

The municipal waste treatment in Finland is divided in 35 different areas and in every area there is a different actor who takes care of the municipal waste. These 35 companies collaborate with 29 government owned or private companies and institutions. In 2009 the Finnish Solid Waste Association, that is the head association for all municipal waste treatment companies, estimated that they treated separately 9990 tons of plastic waste. All in all this was 0,4% of all the waste that they collected (all waste approximately 2,6 million tons). Here it is noticeable that much of the plastic waste ends up as residual household waste and is thus never treated separately from the other waste that households generate. From the total waste, 54% was reused in some way, either incinerated or recycled, 46% ended up on landfills. 18% of the total municipal waste was used as energy recovery. Municipal waste treatment companies do not recycle the plastic waste into raw material, they use all of it as energy recovery and burn it. The aim however of the municipal waste treatment companies is to get better at recycling materials to proper reuse applications. For example in the upcoming years packaging materials will be of a particular interest and the possibility to recycle and reuse packaging materials will be investigated. In the future the capacity of incinerating waste will also be expanded. [8]

Different plastic streams require different ways of dealing with them and this is why some private companies have found a business in recycling plastics. Most of these companies also recycle other materials and recycling plastics is just one part of their business. The Association of Environmental Enterprises in Finland is a head organization for private companies that treat waste in Finland. According to this association there are 30 companies in Finland that are able to handle plastic waste. Most of these companies

deliver the waste to energy recovery burning but some companies collect bright plastic films that they ship further to cooperative companies that convert the films into recycled raw material. Then there are a few companies that are able to recycle larger amounts and different sorts of plastic waste to raw material. Examples of these companies are Lassila & Tikanoja Oyj, Stena Recycling Oy and Kuusakoski Oy. [9] There are also some other companies that recycle plastics, these are mainly companies in the plastic business and they benefit from recycling both their own waste and others waste plastics. Examples on these companies are for example Ekiplast Oy and Muovix Oy. [10]

2.3 Legislation and directives

Laws and directives are needed in waste management so that waste is treated in a systematical and environmentally friendly way. The laws for waste management are usually made on a national level and they are accustomed to directives, decisions and regulations that are given out on a European level. So the directives show in which direction the different countries should progress when handling waste and what should be the end use for different wastes. There are a lot of different European Union directives that all focus on handling waste so that the minimum damage would be made to the environment, many of these needs to be considered also when collecting plastic pipes for recovery. The EU waste legislation can be divided into "framework European Union legislation on waste", "European Union legislation on waste management operations" and "European Union legislation on specific waste streams". [11]

"Directive 2006/12/EC of the European Parliament and of the Council of 5 April 2006 on waste (this is the codified version of Directive 75/442/EEC as amended)" and "Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives" handles many general things that should be considered when handling waste on a national level in different member countries. For example it tackles waste hierarchy which means that the first thing to do with waste is to prevent it, then reuse it, recycle it, recover from it or as a last possible method dispose it. This directive also states that establishments that are handling waste need to have a permit from local authorities and that incineration must only be used if it is energy efficient. Further it suggests that member states of the EU should have nation-

al planning for waste management. Summarized, these directives create a legal framework for the treatment of waste and the main objectives are to protect the environment and human health both in the generation of waste and in waste management. Other directives, decisions or regulations that make up the framework of waste legislation are "Regulation (EC) No 1013/2006 of the European Parliament and of the Council of 14 June 2006 on shipments of waste" aims at controlling the shipment of waste materials in the European Union, this could be applied if the plastic pipes would be shipped to another country. "Decision 2000/532/EC establishing a list of wastes, as amended" defines different types of wastes and how to handle these. [11]

Other EU legislation that has to do with this research is "Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste" that puts strict operating conditions and technical requirements on incineration so that pollution of air, water and soil is minimized and human health is not affected negatively. There are several different directives, decisions and regulations that go deeper into certain subjects like landfilling (Council Directive 99/31/EC), hazardous waste (Directive 2008/98/EC articles 17 to 20), waste from specific waste streams (biodegradable waste, ELV, WEEE etc.) and waste from specific activities, for example the industry (Directive 2010/75/EU). [11]

In Finland the waste law (1072/1993) and the environmental protection law (YSL 86/2000) give guidelines to recycling. The waste law has been renewed and will come into force in May 2012. The new legislation uses the EU directives as a guideline and is an update of the old legislation. In the case of plastic pipes recycling it is more interesting to look at laws that regulate private companies and their waste management. Like the waste law still states, private companies have the freedom to choose what happens with their waste and if they choose another company to handle their waste it is important to know that the company that handles the waste should according to the environmental protection law have an environmental permit to do this. Municipalities are responsible for taking care of their own waste. The new law highlights producer responsibilities for example in the packing industry but this does not concern the plastic pipe producers and their products and it also aims at making landfill fees high enough so that it encourages recycling. The national goal in the new waste law is to reduce the annual

amount of municipal solid waste to 2,5 million tons, increase composting capacity to 320 000 tons, the capacity for material recycling to 750 000 tons and the energy recovery capacity to 1 million tons per year. The aim is that in 2016, 50% of the municipal waste is either recycled as material or recycled biologically and the rest will end up as energy recovery. The increase in different waste handling capacities on the municipal side most surely also benefits private companies and their recycling. [12][13]

2.4 Plastic pipes

2.4.1 Benefits

Why choose plastic pipes instead of for example metal pipes or other solutions? The following arguments are in favor of plastic pipes [14]

- Sustainability
- Energy Efficiency
- Flexibility
- Long track record
- Less leakage
- Low operational costs

These points need to be explained better. Plastic pipes are a sustainable solution. With this it is meant that not only is plastic a sustainable solution as a material but it can also provide sustainable solutions in different branches. For example "rainwater harvesting and management, storm water drainage, domestic grey water systems, district heating and domestic geothermal technology" are areas where plastic pipes are contributing to creating a more sustainable world. As a material plastic pipes are also sustainable because processing them is not very expensive (compared to metals), in other words they are energy efficient. "Many more meters of pipe can be made from one kilo of plastic than any other pipe material". The pipes can be recycled both to recycled raw material and to alternative fuel through energy recovery. [14]

“Plastic pipe systems have a successful track record of more than 50 years”. The life expectancy of the pipes is up to a hundred years. With modern technology there has been development in this and nowadays it is possible to make pipes that have a life span of hundred years if they are installed under correct conditions. Flexibility comes from the possibility to form plastic into a desired shape. It is much less energy consuming to create complex shapes with plastics than with metals. Flexibility also describes the possibility of plastic pipes to adapt to their surroundings. “In buried installations the flexibility of the pipe system is able to cope with movements in the soil. During soil compaction, the pipe follows the settlement of the soil, avoiding that excessive stresses are created in the pipe wall”. Because of the visco-elastic behavior of plastics the stresses in the wall of the plastic pipe remain low and thus results in better performance in practical use. Plastic pipes are economical to install, operate and maintain. Because of their light weight it is easy to mount them and because of good performance they do not need to be maintained very often. With new technology plastic pipes can be used in almost any application where pipes are needed and in combination with the good properties concerning installment and maintenance, plastic pipes are also an economical solution. The easy formability of the plastic pipes also leads to less leakage. The sealing of the pipes can be made so that it is very unlikely that any leakage occurs. [14]

2.4.2 Applications

As mentioned before, plastic pipes can be used in almost any piping application. Since plastic piping became more popular in the 1950s and 1960s, more and more plastic piping has been used in different applications. Here are some of the most important applications and more information about them and what plastics are used in each different application [14]

- Drinking water

  To get clean drinking water is essential for humans. Plastic pipes minimal leakage both from inside to outside (water loss) and outside to inside (pollution) is a very important feature in providing people with drinking water. “Plastic pipe systems are used in every aspect of the water cycle, from abstraction, to treatment, to distribution, to collection and back to treatment.” PE, PP and PVC are

used in this application depending if the pipes are transport and distribution lines or if they are sleeves or casings.

- Sewer

  The good properties of plastic pipes when installed into the ground and the fact that almost no maintenance is needed are an important factor for sewage systems all around the world. The sewage treatment is maybe not a very popular subject but a necessary subject to say the least. Plastic pipe systems are used for plain sewage systems and waste water transport. Mainly PVC is used for these.

- Gas

  In long term solutions for gas and energy distribution it is important that the distributions system is corrosion free and without leakage. Plastic pipes are very suitable for this application because they fulfill both requirements. The flexibility of plastic pipes is also very important in many of the applications because in extreme environments, like during an earthquake, the pipes can not brake and start leaking. This is an important feature of the plastic pipe systems in many different applications. Also "long-term resistance to a variety of service conditions such as abrasion, temperature, bending, weathering and internal pressure" makes plastic pipes a superior option for gas distribution. PE is used in this.

- Hot and cold water

  Non-corrosive, pressure resistant, hygienic, resistance to a big enough temperature range and good sealing are properties that need to be fulfilled in handling hot and cold water. Plastic pipe systems are able to provide these properties. Special plastics are needed for hot and cold water transition so PEX and PE-RT are often used.

- Soil and waste

  Very similar properties are needed in this application as in hot and cold water distribution. One more thing that is important in soil and waste systems is noise insulation. This property leads to less noise and thus more comfortable living environments. Mainly PP and PE are used in these applications.

- Heating and cooling

  The low thermal conductivity of the plastic materials makes plastic piping very suitable for both heating and cooling applications. The flexibility and possibility to make jointless pipes also makes plastic pipes suitable for under-floor-heating. More advanced materials are needed for these pipes and the most commonly used plastics are PEX and PE-RT.

- Rain water

  Rainwater harvesting and dispersal which means that rainwater is collected from roofs and streets is a part of ecological thinking. Also very intense rainfalls due to small changes in climate have increased the need for drainage systems so that floods can be avoided. PVC and PP are used for these.

- Cable protection or conduit

  Plastic pipes are also used for other kinds of applications than for moving fluids and gases. A rapidly growing amount of cables occupy the grounds beneath us and walls around us. These cables need protection against corrosive forces and they need to stay fully operational all the time. Plastic piping also makes the maintenance of the cables easier if something needs to be repaired. “Subsequent excavations, road construction, hurricanes and even rodents is” less likely to harm the cables if they are protected by a plastic cover. PE and PVC are most commonly used for cable protection.

- Industrial systems

  Plastic piping is used in many different manufacturing and industrial purposes. If some special properties are required in a process, plastic piping can offer high purity and corrosion resistance. Different grades of PVC and PP are used for this.

- Irrigation and land drainage

  Like in rain water applications, also here plastic pipe systems are used in a similar way. Plastic piping is a very good option for example for crops and horticul-

ture and a piping system can deliver the exact amounts of needed water to a specific location. PE, PP and PVC is used for this purpose.

2.4.3 Materials

As seen in the chapter about plastic pipe system applications, many different plastics are used to produce plastic pipes. The most relevant plastic types for this research are polyethylene (PE), polypropylene (PP), polyvinyl chloride (PVC) and cross-linked polyethylene (PEX) because the collecting of plastic pipes for recovery in Finland focuses mainly on these four plastics and their under categories. These plastics vary in both technical and physical behavior and thus they need to be compared to understand the difference between them and why they are used in certain applications.

- PE

  Polyethylene is a polyolefin, which means that it is a polymer built from hydrocarbons with a double bond. Polyethylene is a semi-crystalline thermoplastic material and depending on the method of polymerization, the properties are affected in different ways. Different polyethylenes are categorized by their densities. There are several different polyethylenes, for example low density (PE-LD), medium density (PE-MD), high density (PE-HD), linear low density (PE-LLD), high density ultra high molecular weight (PE-HD-UHMW) and so on. "PE properties can be customized for specific fields of application by the use of additives". The chemical structure for polyethylene is

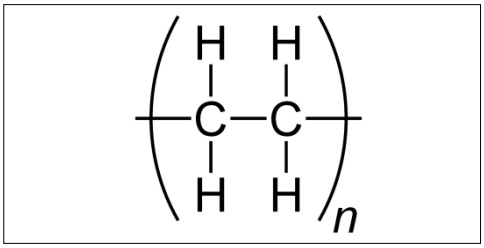


Figure 4 Chemical structure of polyethylene [51]

Different polyethylenes are used in different applications. PE-LD is used in many different film applications, pipes, wire covers, coating of steel pipes and canisters. PE-HD is used in bigger containers, trash cans, high-pressure pipes, fittings for drinking water supply, fittings for waste water disposal and fuel

tanks. The more modified polyethylenes like PE-HD-UHMW can be used in demanding applications like machine elements (pulleys, gears, bushings and rolls), surgical implants and prostheses. [6]

- PP

  Polypropylene is also a polyolefin but different in chemical structure as polyethylene. Polypropylene is polymerized from propylene and is also a semi-crystalline thermoplastic material. As a difference to polyethylene, polypropylene has higher strength, higher stiffness, a higher crystalline melting temperature and a lower density. PP can be tailored to different uses and made into high molecular homo- and copolymers. The chemical formula for PP is

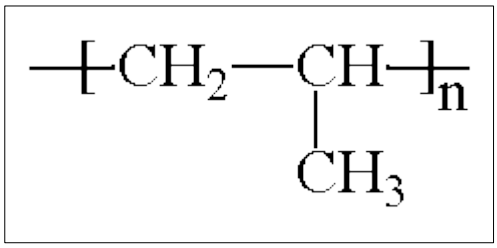


Figure 5 Chemical formula of polypropylene [52]

The hydrogen (H-) molecule in PE is replaced by a methyl group (CH_3-) and depending on how the CH_3- groups are arranged in the PP chain (isotactic, atactic, syndiotactic), the material can get different properties. Because of these properties PP can be used in an exceptionally wide range of applications. For example in automotive PP can be used from dashboards to sound absorbing interiors, in mass production cups, food containers, tool boxes and suitcases can be made out of it and it is widely used as a casing material for electronic products both in households and elsewhere. PP is used in a wide variety of processing methods from which injection molding, extrusion and blow molding are the most common ones. In piping PP is most suitable for high-pressure warm water and waste water pipes. [6]

- PVC

  Polyvinyl chloride is a vinyl polymer. The major difference to polyolefins is the polymerization process, basically how the vinyl polymers are produced. PVC is

a thermoplastic polymer and can be found in rigid form (without plasticizer), in a soft form (with plasticizers) and as a paste. PVC has high rigidity and a high modulus of elasticity but low abrasion resistance, low impact resistance at low temperatures and long term alternating fatigue strength. The chemical composition of PVC can be seen in figure 6.

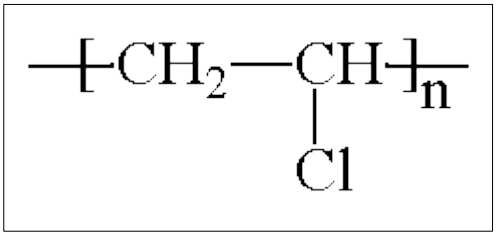


Figure 6 Chemical structure of polyvinyl chloride [53]

PVC is resistant to a great number of different liquids and solutions, for example alcohols, gasoline, mineral oils and fats. This is why PVC is a very good material to use in pipe systems. Applications where PVC is used are for example pressure pipes, drainage pipes and waste pipes [6]. "Considering that about half of PVC is in use in long-life products and lifespan of such PVC products is about 30-40 years, a significant increase in PVC waste generation is also expected in the near future" [15]. Because of this long lifespan PVC is also very suitable for plastic pipe applications.

- PEX

  Cross-linked polyethylene or PEX is as the name indicates a polyethylene that has cross-linked polymer chains. The cross-linking is made in 3 dimensions and by cross-linking the PE "creep resistance, low temperature impact resistance and stress cracking resistance are considerably improved". Hardness and stiffness are however a little bit reduced. The cross-links can be made in many different ways, for example peroxide-cross-linking, silane-cross-linking and azo-cross-linking. In all processes the links between the polyethylene chains are a little bit different. [6]

  PEX behaves like an elastomer and will not melt and thus can withstand long term temperatures up to 120°C and short term temperature loads of 250°C. Ap-

plications for PEX are “medium- and high-voltage cable coatings, pipes for hot water and radiant heating installation, parts for electrical engineering, chemical engineering and automotive applications”. [6]

The properties of the polymers are quite different and that is why a comparison needs to be made so that the different uses and different application of the materials can be better understood.

Table 5 Crucial properties of the different plastics used in plastic pipes [6]

	PE-LD	PE-HD	PP	PVC	PEX
Density (g/cm³)	0,92	0,96	0,9	1,55	0,96
E*t* (Mpa)	200-500	700-1400	1100-1300	1000-3500	none
T*m* (°C)	110	110	160-170	100-260	none
Service temperature (°C)					
max short term	80-90	90-120	140	75-90	250
max long term	60-75	70-80	100	65-70	120
Energy content (kWh/kg)	>10	>10	>10	>4-7	>10

In table 5 it can be seen that the density of PVC is different from the other materials densities. This means that by for example floating, PVC can be separated from mixed plastic waste deliveries. Most of the PVC waste sinks and the other ones float. Because PEX behaves like an elastomer, it does not have any values for E_t or T_m. From the service temperature comparison it can be seen that PEX is the most tolerant one and is thus used commonly in heating pipes and other rougher environments than the other plastics. In the energy content section we can see that polyolefins have a higher energy content than PVC and give thus more energy when incinerated.

2.5 Plastic pipe recycling in other countries

Finland is in comparison to other countries an average country in plastics recycling. With a recycling rate of 16%, a recovery rate of 41% and a waste kilograms per capita number of 37 Finland is situated in the middle of every comparison table [3]. To be precise Finland is a little bit below average because the recycling rate and recovery rate for

whole Europe are 22,5%, respectively 54%. The plastic waste kilograms per capita in Europe is in average 47.4 kilograms. On top of the tables are countries where recycling has been a popular topic for a longer time and where energy recovery levels are very high because of "significant energy recovery capacities available" [3]. In figure 7 it can be seen that there is a dark blue belt in the middle of Europe. These are all countries that have a recycling rate of 80% or even higher. Here for example Norway, Sweden, Denmark, Belgium, The Netherlands, Germany, Luxemburg, Austria and Switzerland can be found. There are also countries in Europe that still have a recovery rate under 20% and these are Cyprus, Greece, Romania, Bulgaria, Lithuania and Malta. [3]

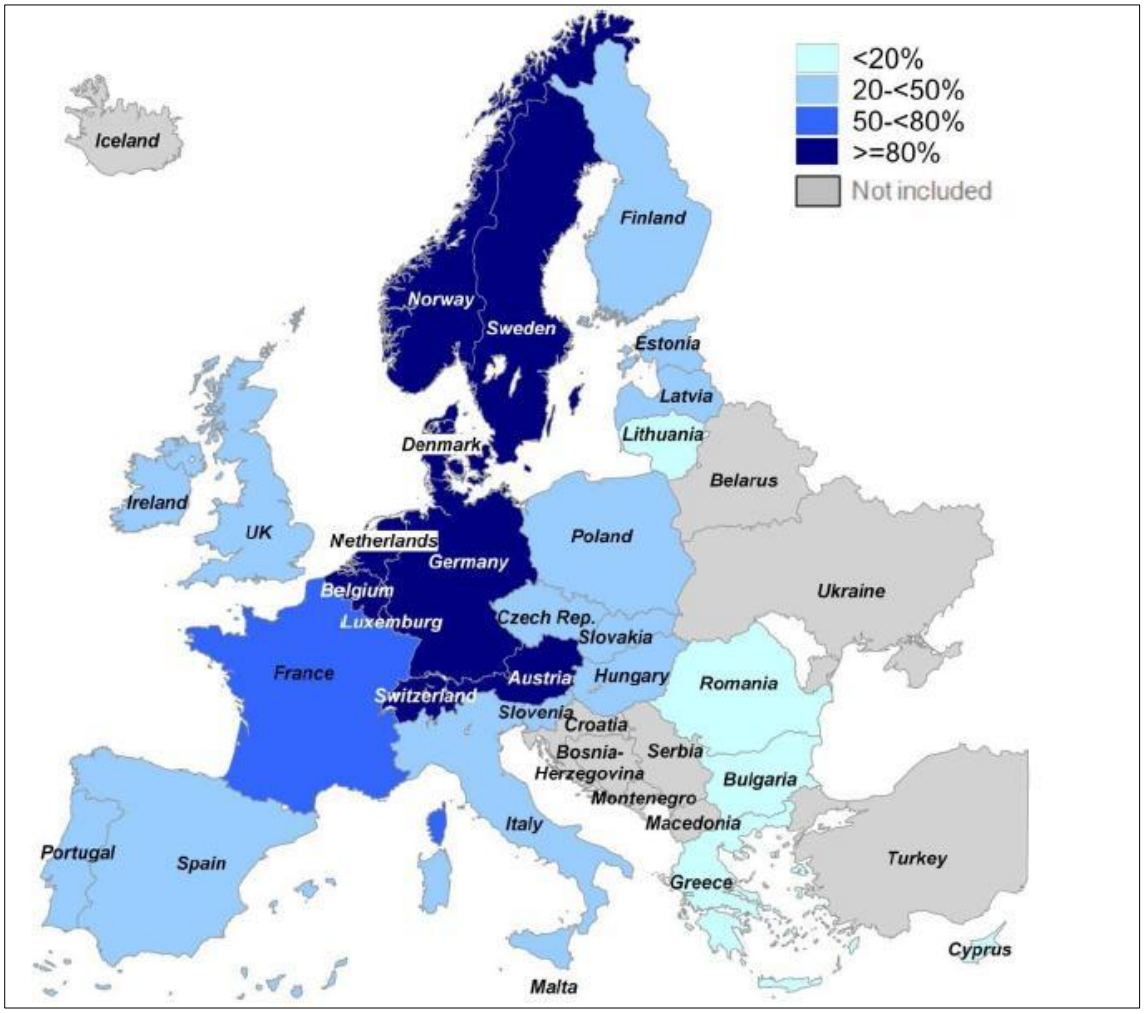


Figure 7 Map of Europe with different countries recovery rates in plastic recycling, excluding Russia [3]

Naturally, if the recovery rates are high, it usually indicates that plastic pipe collecting and recycling is done quite well also in these countries. To see how exemplary countries deal with their plastic pipe waste it is good to see how their collecting and recycling sys-

tems work. The following sub-chapters will handle the Swedish, Dutch and the German systems.

2.5.1 Sweden

In Sweden the plastic pipe collecting and recycling is taken care of by a company called Swerec Ab that is in contract with Nordiska Plaströrsgruppen (Nordic Plastic Pipe Association: NPG). This association consists of member companies that are all involved in plastic pipe production or plastic raw materials delivery and production. Examples of member companies are KWH Pipe Sverige Ab, Pipelife Sverige Ab, Uponor Ab, Wavin Ab, Borealis Ab and Ineos ChlorVinyls. This system has been running since 1996 and during the first 10 years over 1400 tons of plastic pipe waste has been collected and recycled. The system collects PE, PP and PVC pipes and pipe parts and the system is paid by NPG member companies. Also wholesalers are a part of the system and cooperating in the collecting of the pipes. Since 2007 also strategically located municipalities have been included in the system. [16]

It is free to deliver plastic pipe waste to the containers but it is on every companies own responsibility to make the actual delivery. The advantage that companies get from delivering the pipes to collecting containers is that they avoid a landfill fee of 600-1000 Swedish crowns (approximately 65-110 euro) for each ton of waste. So the Swedish system is quite similar to the one used in Finland today with collecting containers. When the pipes are collected in containers they are shipped to a company that sorts, washes and recycles the pipes to new raw materials. So that this would be as cost effective as possible the pipes have to be clean from any outside pollution and they can only be of the three materials mentioned before. There is also a limitation that only pipes produced by KWH Pipe, Pipelife, Uponor and Wavin are collected into the containers. [16]

The actual collecting happens at strategically picked locations and environmentally aware municipalities. Also water management facilities collaborate. The focus is on southern and the middle parts of Sweden. 9 containers all the size of 35 cubic meters are used for the collecting and all containers are marked NPG so that people know that they

are for plastic pipe recycling. To be able to bring pipe waste to the container an agreement always needs to be made with the container manager. If bigger amount of plastic pipe waste is generated somewhere else where a container is not located at a reasonable distance, Swerec can also pick up the pipes for the price of the transportation fee. [16]

In 2010 the NPG plastic pipe collecting and recycling system handled 117 tons of waste. All this handling cost approximately 565 000 crowns which is about 61 200 euro. So the cost for the system is around 520€/ton. 54% of the cost is sorting and crushing, 21% is the rent for the containers and 25% is logistics costs. [17]

2.5.2 Holland

In Holland there has been a system for plastic pipe recycling already since 1991, so it has been operational now for 20 years. The system is called BIS (Buizen Inzamel Systeem) which basically stands for the Dutch plastic pipe waste recovery and recycling system. It is operated by Bureau Leiding which is the Association of Plastic Pipe Manufacturers in the Netherlands. This system was the first plastic recycling system in Holland. [18]

BIS recycle PE, PP and PVC and the biggest amount of plastic pipes in Holland are of PVC. The BIS system has lost some of its importance in recycling PVC after the Recovinyl project started in Europe. A lot of the PVC pipes are nowadays handled by companies that are in the Recovinyl program and BIS has concentrated more on PE and PP. Recovinyl is a program that "provides financial incentives to support the collection of PVC waste from the non-regulated PVC waste streams" [19]. When BIS was founded the main principles behind it was not to make business but to create awareness and enable plastic pipe recycling. After this, other companies have entered the market and nowadays only 20% of the total plastic pipe waste is taken care of by BIS. The market has taken over a major part of the recycling business and this is seen as a positive development. The BIS system is owned by the industry and this is acknowledged by the government and much appreciated but the companies do not get any financial advantages by being a part of the system. [18]

BIS also uses a container based collecting system and has close to 85 collection points around Holland. They also provide a pick-up service where the company that makes the pick-up order pays for the transportation, the sorting and the amount of waste that needs to be transported. The total volume of PVC pipe waste in Holland annually is estimated to about 12 000 tons, of which BIS handles approximately 1500 tons. BIS recycles 450 tons of PE every year and around 100 tons of PP. All in all BIS recycles over 2000 tons of plastic pipe waste every year. The quality of the plastic pipe waste has to be pure. [18][20]

2.5.3 Germany

In Germany Tönsmeier Kunststoff (Toensmeier Recycling) is one of the main recyclers in plastic materials and one of the leading recyclers in Europe. The company has been running already for 35 years and is active nowadays in Germany, Austria and Poland where they have in total 6 recycling facilities. They collect plastics from over 5000 plastics production companies and the collection is done with their comprehensive logistics network and with different size boxes and containers that can be tailored to each company needs. Tönsmeier is a partner of Fachverband der Kunststoffrohr-Industrie (KRV) which is the german federation of the plastic pipe industry. [21]

Tönsmeier collects and returns to the plastic industry over 60 000 tons of thermoplastic waste annually as recycled raw material, both as regrinded and pelletized. Tönsmeier recycles over 4000 tons of plastic pipes every year consisting of PE, PP and PVC pipes. The pipes come from Germany, Belgium and Denmark. They collect both off cuts from companies that have pipelines and old pipes from disposal companies, the companies can deliver the pipes to any of the Tönsmeier facilities or then Tönsmeier can pick them up for a logistical fee. The recycled raw material is sold back to the pipe producing companies and is used mainly to produce new pipes. [21]

3 METHOD

The most suitable method to approach a problem like finding a new system for plastic pipe recycling in Finland is to get to know the parties already involved in the current system and major actors in the plastic recycling business in Finland. Questions that need to be answered are for example, what are the main problems right now with the existing system? Why are the different parties unhappy with the situation? Are there any other existing systems where the plastic pipe recycling could be incorporated? Could the plastic pipe recycling be somehow optimized so that it would work better?

Questions are many but the most important thing is to find companies and parties that are genuinely interested in recycling plastic pipe waste. To get an overall look at the situation right now a questionnaire was sent to customers of pipe producers. After this representatives of the different actors in plastic pipe recycling were interviewed. The companies that produce the pipes (KWH Pipe, Uponor and Pipelife Finland), the wholesalers that sell the pipes (Ahlsell, LVI Dahl, Onninen), major pipe users (waterfacilities like HSY, Skanska, YIT) and companies in the recycling business (L&T, Muovix, Kuusakoski). Also Suomen Uusiomuovi Oy was interviewed to see from their point of view, as an expert in plastic recycling, how the recycling should be carried out.

To be able to understand better the situation some field studies to different locations was also carried out with a camera and some notes.

3.1 Questionnaire

To get an overall look at the situation right now with the plastic pipe recycling a questionnaire was made. It was sent to 499 customers of the three different plastic pipe producers (Oy KWH Pipe Ab, Pipelife Finland Oy, Uponor Suomi Oy). All in all approximately 15% answered the questionnaire (77 answers). There were five questions that covered problems with the current plastic pipe recycling without taking a stand on what could be right and what could be wrong. The actual questions and the results in percentages can be found in appendix 7.1. and in the results section 4.1. [40]

3.2 Interviews

Since there is not too much public information and facts considering plastic pipe recycling it was necessary to get information about the subject in some other way. For this purpose interviewing was a suitable method. In this study some of the companies experience very similar problems, for example wholesales companies like Ahlsell, Onninen and LVI-Dahl. This is why it was not of highest importance to contact all of them so that the most fundamental problems in the current plastic pipe recycling system would be understood. Some of the interviews were made face to face and some were through e-mail. The following persons representing the following companies were interviewed

- Muoviteollisuus Ry, Secretary General Aulis Nikkola
- L&T, Unit Manager Ville Vainio
- Muovix Oy, General Manager Mikko Koivuniemi
- Skanska Oy, Environmental Executive Johanna Pakarinen
- Oy KWH Pipe Ab, Product Manager Tomi Lempinen
- Pipelife Finland Oy, Project Manager Seppo Kuusela
- Uponor Suomi Oy, Application Manager Elsa Launiainen
- Onninen Oy, Quality Manager Ari Nybäck
- Suomen Uusiomuovi Oy, Managing Director Vesa Kärhä
- Kuusakoski Oy, Project Manager Kalevi Koivumäki
- Stena Recycling Oy, Customer Manager Lauri Rantalainen

3.2.1 L&T

The point with interviewing L&T was to find out how interested L&T is in recycling plastic pipe waste, is it profitable for them and would they be ready to give up the containers if there would not be any interest in the plastic pipes anymore. The aim was also to get to know how L&T recycles different materials and how a recycling facility actually looks like. After the interview a small visit to the actual recycling facility was carried out and different recycling processes of L&T were presented.

The outcome of the interview was that L&T does not see the plastic pipe recycling as a profitable business and thus they do not have a high interest in continuing with the system as it has been for the last 12 years. According to Ville Vainio, Unit Manager at L&T, the system is outdated and does not work anymore as it was planned to work. Biggest problem is the logistic cost that is affected by an ineffective way of using transportation space (cubic meters). The pipes are big and require a lot of work so that they would be compressed to a smaller space. The collecting has also failed since there are in the containers all kinds of plastic, not only plastic pipe waste, and this is why it would be more effective to put all plastic waste that is generated on the collecting grounds to the energy recovery container that is at the same location as the plastic pipe waste collecting containers. L&T who owns the plastic pipe collecting containers right now do not need them anymore and if some other actuator would be interested in continuing the plastic pipe recycling, the containers could be sold for a nominal price. The other option for the containers would be to ship them to a landfill and that would cost L&T. Complete interview can be found in appendix 7.2. [41]

3.2.2 Muovix Oy

The idea with the interview was to find an alternative to L&T, another company that would be interested in recycling the plastic pipe waste. The aim was to see what another company would have to offer and if a company with a little bit different interests and of a different size would have new views on the matter. The business idea of Muovix is also very unique in Finland and this is why the whole production process also was of interest. After the interview there was a factory tour that handled incoming material, the processing to raw material and storage.

In the interview General Manager Mikko Koivuniemi pointed out that Muovix would most certainly have an interest in the plastic pipe collecting if that would generate usable raw material for the company. They are working together with HFT Network Oy that could handle the logistics for them (the collecting of the pipes) and they already have some ideas on how the collecting could be carried out in practice. The raw material from the pipes would be most suitable for Muovix and a lot of it could be used in their own processes. Muovix will prepare an offer for the plastic pipe recycling system dur-

ing September month 2011. Koivuniemi also pointed out that Muovix would be very interested in the containers that are used for the recycling. For Muovix it would also be important that other options and collecting points than the ones used nowadays would be looked into. For example construction yards and water management facilities and their pipe waste volumes would be really interesting to know and make a small research if it would be possible to collect pipe waste from these locations also. Complete interview in appendix 7.3. [42]

3.2.3 Skanska Oy

The idea of this interview was to find out how much plastic pipe waste is generated at a typical construction site in Finland. This would give numbers to compare how much waste could be gathered from many different construction yards. (43) Skanska has a new program where they educate environmental executives. Right now they have 14 of these and they all manage a construction site of their own. At these locations recycling is handled very well. Some UVL Talotekniikka Oy subcontractor workers were also interviewed quickly at the location.

Before the visit to Herttoniemi and the Skanska construction yard some questions were sent out to Johanna Pakarinen who is the Environmental Executive at the location. During the visit the questions were discussed. Johanna Pakarinen says that in the construction business material effectiveness has never been considered as important as nowadays. Regardless of this there is still a long way to go for construction yards to be truly material effective. Things that contribute to this are for example working habits at construction sites and the time-cost problem, contractors are usually hired with contracts and that means that time is money. At the yards with the Environmental Executives the recycling is handled quite well. The waste material is collected in every level of the construction and then taken to a gathering point where it is sorted. The exact volumes of waste are unknown but subcontractors estimate that 2-5% of the plastic pipes end up as waste. The main reasons for this are damaged products and leftovers after cutting and fitting. Pakarinen had a small estimation of the amount of waste generated on the site that was visited and the size of the site is known. The entire interview is in appendix 7.4. [43]

3.2.4 Oy KWH Pipe Ab, Pipelife Finland Oy, Uponor Suomi Oy

The meaning with this meeting was to hear what the companies that are paying for the pipe recycle system want from the research and what their main motives are for recycling plastic pipes. They had also the opportunity to tell exactly what they expect from this research that handles the plastic pipe recycling.

At the meeting the different pipe producing company representatives made clear that the most important thing behind putting up a plastic pipe collecting and recycling system is the image of the companies. They want to make sure that the products end up in environmentally friendly uses at the end of their lifecycles. According to Seppo Kuusela, Project Manager at Pipelife Finland, the second most important thing is that the recycling system needs to be credible and effective. The pipe producers do not want to pay more for the system than they are paying now and it would be highly important to make a contract about the plastic pipe recycling with companies that are genuinely interested in recycling the pipes. The pipe producing companies are also interested in recycled material and would like to know prices for example for recycled PVC. In the end Tomi Lempinen, Product Manager at KWH Pipe, said that the research should have a couple of clear suggestions on how the plastic pipe recycling should be taken care of in Finland. The meeting discussions and meeting invitation can be found in appendices 7.5. and 7.6. [44]

3.2.5 Onninen Oy

From Onninen it is important to know how the wholesales companies experience the recycling of plastic pipes. After all, the containers are physically on these yards and that is where the actual gathering of the plastics happens and where the biggest difference can be made to increase the volume of the pipe waste and the purity of the waste that is put into the containers. Wholesalers are also an important source in distributing information about the plastic pipe recycling.

Ari Nybäck, Quality Manager at Onninen Oy, thinks that the plastic pipe recycling has failed on the wholesalers yards. The volumes of the waste are very small and the people that should be taking care of the recycling are poorly informed about their tasks. They

feel that the current system does not create any added value to them or their customers. Interview in appendix 7.7. [45]

3.2.6 Suomen Uusiomuovi Oy

The aim of the interview was to see how a person that has been in the Finnish plastic recycling industry for a long time sees the recycling in Finland and the plastic pipe recycling. Probably the most suitable person to contact in this matter is Managing Director Vesa Kärhä from Suomen Uusiomuovi Oy. He is also the General Manager of Muoviteollisuus Ry. He has been working with plastics his whole career and he has an over 25 year experience of plastic recycling in Finland. Suomen Uusiomuovi Oy is a non-profit company that creates and organizes plastic recycling in Finland.

Vesa Kärhä sees that there are some problems with recycling in Finland and that recycling in general is one of the hardest businesses to run, this because you have to be alert both for customers and waste streams to recycle. He also sees that the image of waste management in Finland is still quite bad and that people are not well enough informed about recycling. Kärhä says that he does not think that the new waste legislation, active from year 2012 further, will change much in plastic recycling. The legislations mainly concerns municipal waste management and plastics in municipal waste are hard to separate so that they could be used in effective recycling systems. Finland is now in the upcoming years increasing its capacity to incinerate for energy recovery and this is probably the most suitable way to treat the municipal plastic waste. Concerning plastic pipe recycling, Kärhä says that the system right now serves better as a public relations booster than an actual recycling system. It would be good to increase the volumes of the system but on the other hand the system could become too expensive if this was done. So with this in mind Vesa Kärhä thinks that a smaller Finnish based company would be suitable to take care of the plastic pipe waste so that the recycling would be effective and all parties would be satisfied with it. The years that have passed with the current system have shown that the wishes to increase pipe waste volumes from a bigger company are hard to match. Interview in appendix 7.11. [46]

3.2.7 Kuusakoski Oy

The objective with the interview with Kuusakoski Oy was to get the opinion in the plastic pipe recycling from a leading recycling company in Finland. Kuusakoski is the biggest recycling company in Finland by recycled tons and during the last 5 years they have been focusing more and more on plastic recycling. As a difference to L&T, Kuusakoski is aiming to minimize the energy recovery waste and recycle as material more or less everything they can. In comparison to Muovix, Kuusakoski is a much bigger company (the second largest privately owned enterprise in Finland) and they function in 11 countries. This way the views of a major contributor in the business would be heard.

Kalevi Koivumäki, Project Manager at Kuusakoski Oy told in the interview that Kuusakoski would absolutely be interested in recycling plastic pipe waste in Finland. The company is already recycling construction waste and they have a deal with water management facilities that they pick up their pipe waste. Kuusakoski also has a lot of cooperative companies in the 11 countries where they function and in this way they are able to recycle as a material a wide range of products, for example they have ELV recycling and WEEE recycling. In Finland Kuusakoski has a facility in every bigger population central and their logistics and recycling system is widely spread throughout the country. They recycle each year over 20 000 tons of plastics and 90% of this ends up as raw material and 10% ends up as energy recovery. In Finland they are cooperating with for example Suomen Käyttömuovi Oy and Ekiplast Oy to be able to recycle the plastic products back to raw material. Kuusakoski would like to see the plastic pipe recycling in Finland as a long term partnership that would be each year developed further so that bigger volumes of plastic pipe waste could be gathered by the system. 100 tons of waste a year would be an absolute minimum and in the beginning it could be a little less. Kuusakoski is possibly planning on making investments in the future for plastic recycling. The entire interview can be found in appendix 7.10. [47]

3.2.8 Stena Recycling Oy

The interview with Stena Recycling Oy was made because it is good to compare two bigger companies and see if they would offer similar solutions to the plastic pipe recy-

cling or if they would function differently. Stena Recycling is quite similar to Kuusakoski Oy except they do not have any logistics of their own, they have outsourced this.

According to Customer Manager Lauri Rantalainen, Stena Recycling is not very established in Finland yet as a plastic recycler. They are however growing in this business and they are working every year more with plastics. They are widely spread throughout Finland and they could receive plastic pipe waste at any of their facilities. They have a crushing facility in Pusula and non-contaminated plastic pipe waste could be easily converted into crushed recycled raw material here. The entire interview is in appendix 7.12. [48]

3.3 **Field studies**

To see how the plastic pipe recycling actually works on location some field studies were carried out to different locations. The first location was the LVI-Dahl wholesales yard in Vantaa. First observation was that the container was labeled “plastic waste” (Figure 8) though the aim with the container is to collect plastic pipe waste, not just generally plastic waste. Another observation was that the container looked a little bit rusty and the stickers on it had vanished and were unrecognizable. The inside of the container was surprising considering that the container is for collecting plastic pipe waste. In the container plastic foam, plastic packaging material and some plastic pipes could be found, as seen in figures 9 and 10. When further analyzing the environment where the container is situated, the conclusion can be made that it is located quite separately from the other containers that are situated close to the loading docks.

Figure 8 On the left hand side the sticker on the container saying plasticswaste (muovijäte) and on the right hand side the plastic pipe collecting container on LVI-Dahl wholesales yard in Vantaa

Figure 9 Plastic waste inside the container

Figure 10 Close up of plastic waste in the container where foam, packaging material and pipes can be seen

Figure 11 Other containers than the plastic pipe recycling container close to the loading platform

Figure 12 The wholesales yard, on the left hand side the plastic pipe collection container and on the right hand side same vehicles can be seen as in Figure 11

The second location was a visit to a Skanska construction yard in Herttoniemi Helsinki. This yard was one of 14 pilot projects where they have an Environmental Executive to see that recycling and material efficiency are taken into consideration. There it was seen what kind of waste is gathered on construction grounds and how it is collected. The waste was first collected in different floors of the building and then all gathered on the yard in one big pile. Before the visit to this Skanska yard some of the sub-contractors had just taken a couple of 800 liter sacks full of plastic pipes. During the whole time the construction yard had been there, almost double the amount of waste had gathered on

the yard than there was now. The waste was mainly PVC pipes and they were collected iin a very organized manner.

Figure 13 Picture of the plastic pipe collection point at the Skanska construction yard in Herttoniemi

Figure 14 Three close-up pictures of the pipes on the construction yard

The third and fourth locations were the HSY (Helsingin Seudun Ympäristöpalvelut) storage yard in Pasila, Helsinki, and YIT construction yard also in Pasila. After calling

several persons at HSY a contact was established with Unit Manager Sami Sillsten. He told that most of the plastic pipe waste is generated when actual pipelines are being serviced and temporary pipelines need to be put up. When the lines are fixed the temporary lines are taken apart and are considered after this to be waste. HSY collects all plastic pipe waste that they contribute to on their storage yard in Pasila and they have a deal with Kuusakoski Oy that when the container gets full they call Kuusakoski and they pick up the waste. On the yard there was also many other Kuusakoski containers and pieces of pipe that are stored for later use. According to Sillsten, HSY tries to use as much as possible of the plastic pipe material but they are not very good yet at recycling. The recycling will be an important issue in the upcoming years.

Figure 15 The plastic pipe waste on the HSY storage yard

Figure 16 On the left hand side the container on HSY storage yard that is used for plastic pipe waste collection and on the right hand side a sign on the container saying "plastic waste, only sewage pipes and water pipes"

After contacting a lot of people from YIT a contact was made with Unit Manager Jari Rautala. He told that YIT does not recycle the plastic pipes separately. They have on the construction yards a sorting point where they try to separate as many materials as possible because after this they take the material to a Sortti-station (operated by HSY) which means a station for returning waste material. Here the better the material is sorted the cheaper it is to get rid of it. Usually YIT is not the main contractor in piping and such phases on construction yards and the main responsibility for the recycling on the location is on the main contractor. Rautala also told that subcontractors usually take care of their own waste. All parties on construction yards try to use the material available as effective as possible. When asked if it would be a good idea to start sorting plastic pipes separately on construction yards Rautala thinks that it could work as long as every actor on the yard would use the same system. When making a fast visit to the construction yard in Pasila the local contractors said that they do not have any system for recycling plastics. Metals and other waste are separated and sub-contractors take care of the waste that they produce.

Figure 17 YIT construction yard in Pasila, no plastic recycling was carried out at this location

4 RESULTS

4.1 The Questionnaire

Results from the questionnaire are described in the following section with graphs and explanations.

The first question was about what area of business the companies that received the questionnaire represent. The answers were given in the following manner.

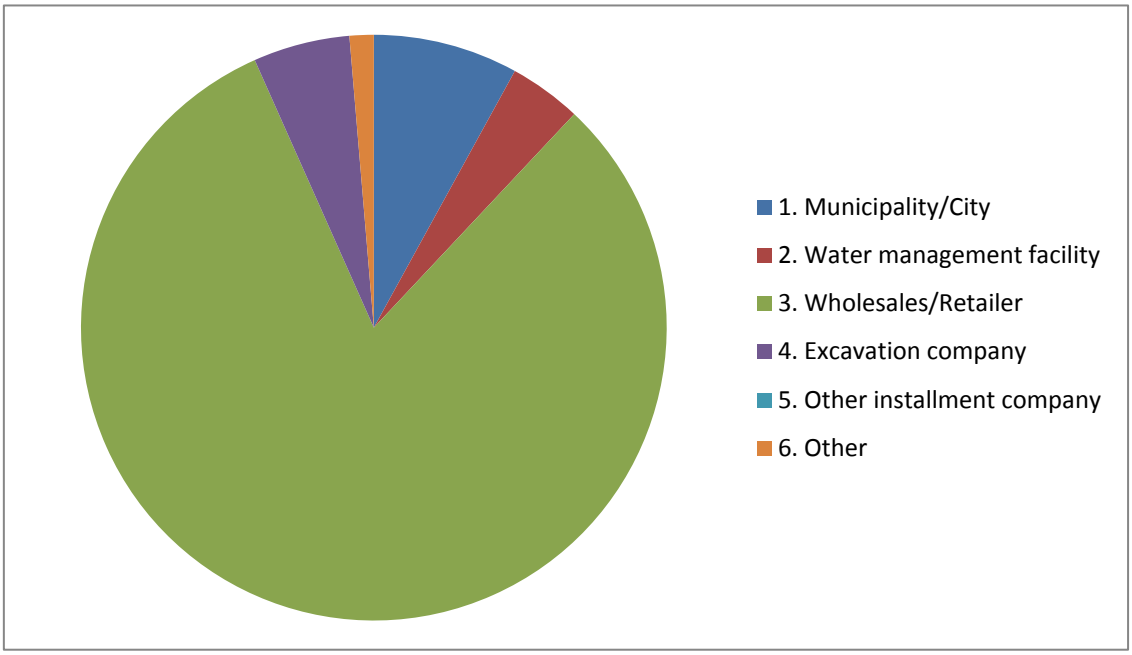


Figure 18 Answers to question one: What area of business do you represent?

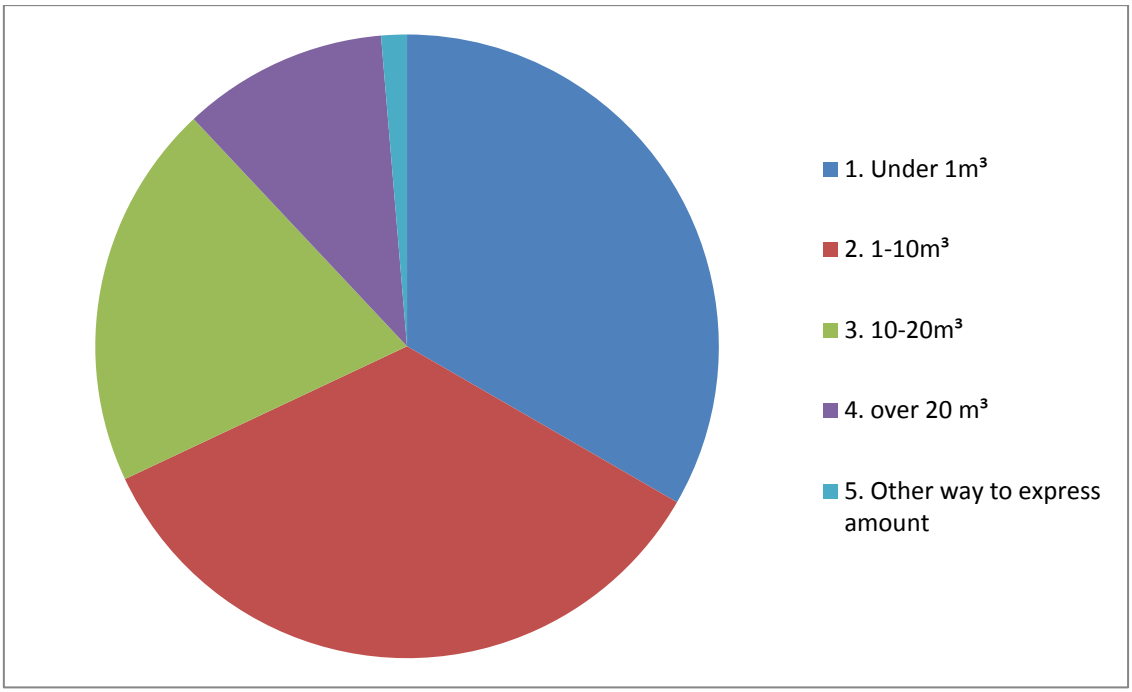


Figure 19 Answers to question two: How much plastic pipe waste is generated annually from your actions?

The second question handled amounts of plastic waste, how much plastic waste is generated. Every company answered for themselves.

The third question was about what the plastic waste consists of. Different companies have different products in use and the waste is of different quality.

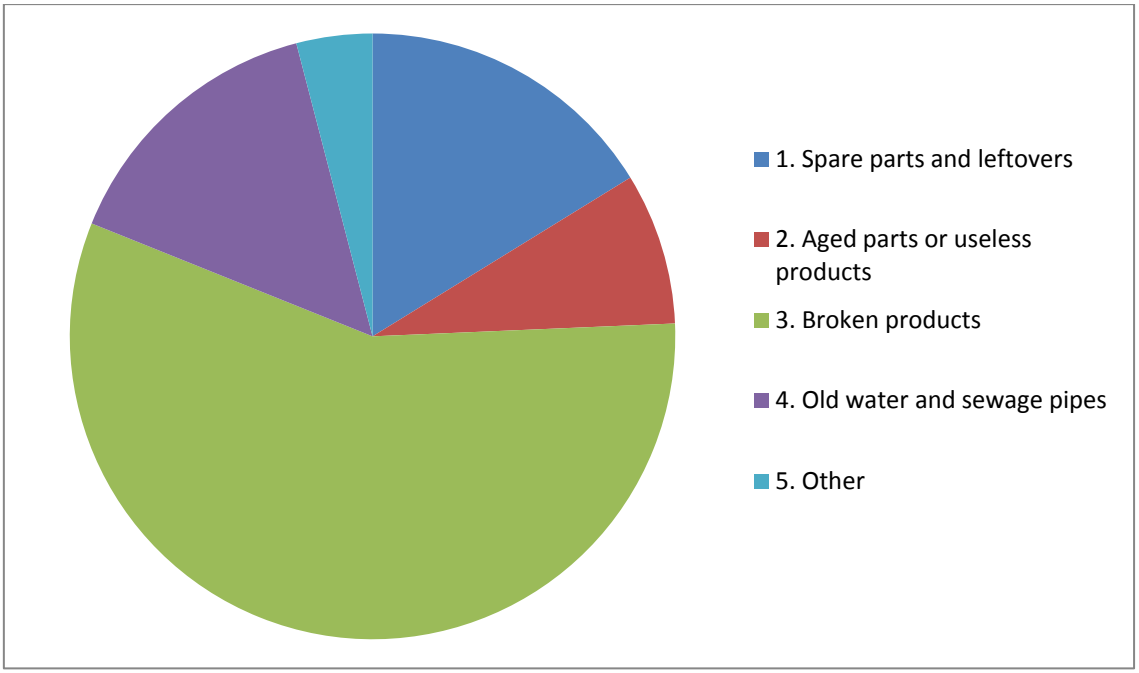


Figure 20 Answers to question three: What does the plastic pipe waste consist of in your field of business?

The fourth question was about handling the plastic waste, what does companies do with it and where does it end up.

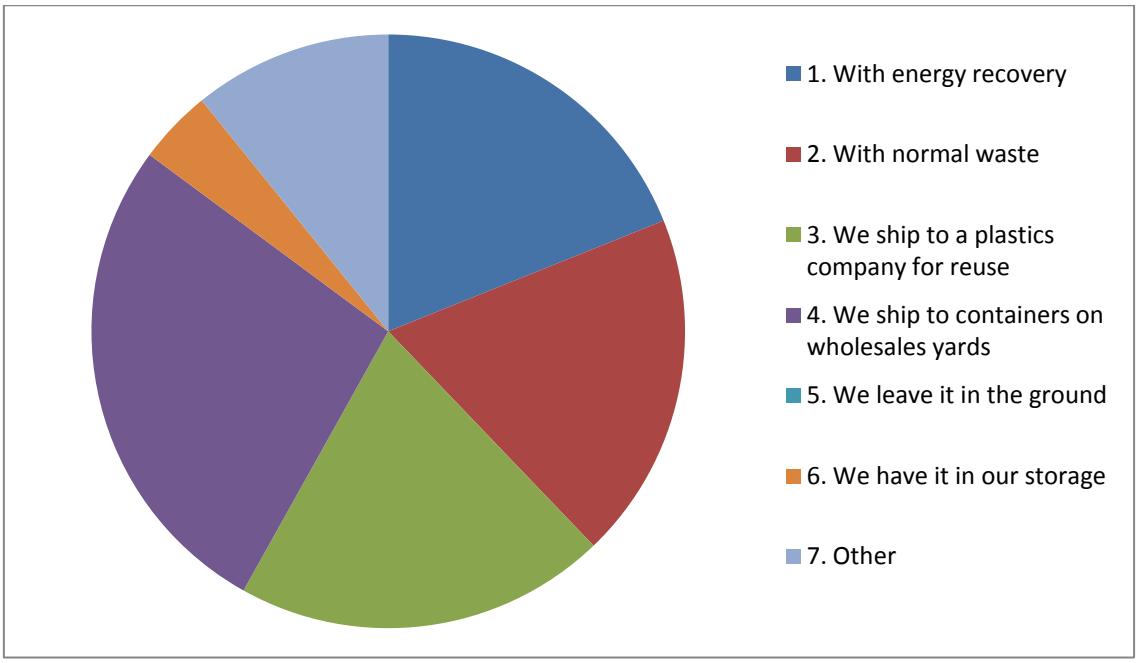


Figure 21 Answers to question four: What do you do with plastic pipe waste nowadays?

The fifth and the last questions was about the future and how to make things better, it was about what would be the easiest way for the companies to get rid of their plastic pipe waste.

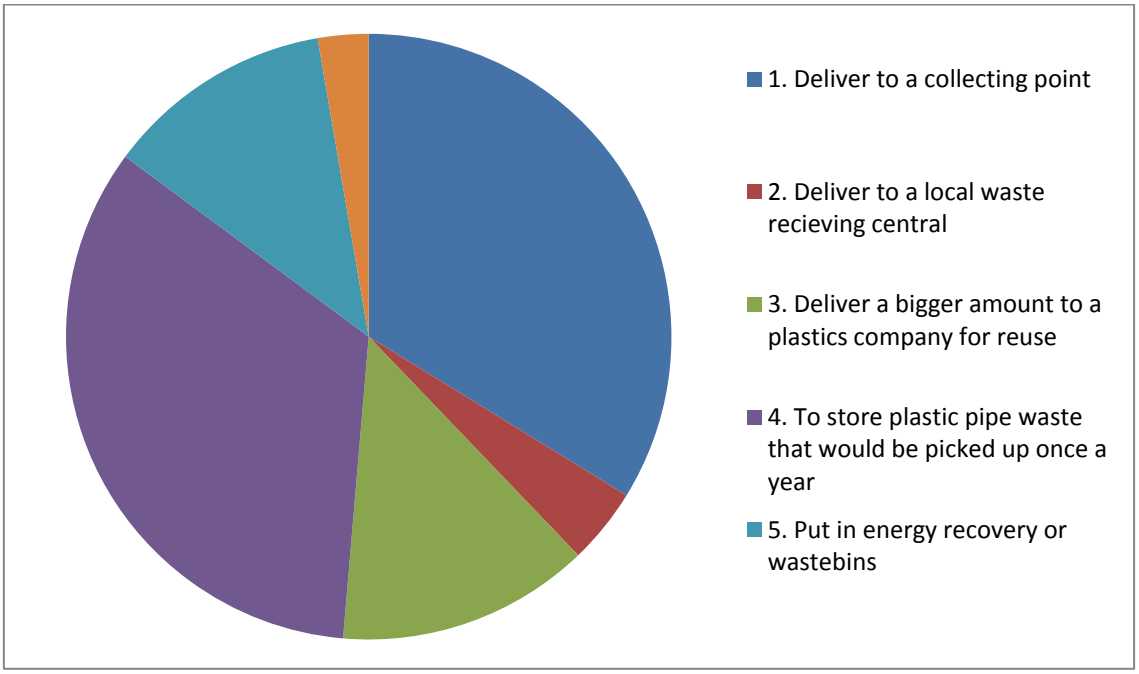


Figure 22 Answers to question five: What would be the easiest way for you to get rid of plastic pipe waste?

In the questionnaire it was also possible to give suggestions on how the plastic pipe waste could be collected and how the system should be developed. Many suggested that it would be good if there was a truck going around from location to location picking up the waste that has been gathered locally, in this case in different companies. Companies would be ready to store the pipes until they are picked up and the pickup would be suitable once or twice a year. Other ones made comments about that construction sites could also bring their waste plastic pipes to collection on wholesale yards and other ones say that wholesale yards are soon turning into landfills where people can dump any waste, that is why it would be better to be able to dump the plastic pipes on an actual landfill without any fees and here the plastic pipes could be sorted and taken further for processing. Many wish that the containers where the pipes are collected should be big enough so that longer pipes would fit, and it would be good to have a crushing machine close to the container so that the pipes could be fitted into a smaller space or more pipes would fit in the containers.

4.2 Cost calculations

The most important part of this research was to find out different costs for different systems because this is the most decisive thing when the Pipe Group is going to make a decision on which company to choose for the plastic pipe recycling. After long discussions with the most interesting companies that could be involved in the plastic pipe recycling, it was noticed that getting exact numbers on how much the recycling costs is very hard. There are many factors that contribute to the final price and different companies calculate the costs in different ways. On top of this the companies also function in different ways and thus it is hard to compare them precisely because ones price does not include the same services in another company. The following prices for the following companies were however found out. To be able to compare the prices the volume of plastic pipe waste during one year is expected to be 100 tons. The calculations are based on numbers that were achieved during discussions with the companies, no theoretical base could be used because different companies contributed with different numbers.

4.2.1 Kuusakoski Oy

Kuusakoski offers a package solution and they have not told exact costs of their recycling system. For PE granulate that has gone through the whole recycling process Kuusakoskis offer is [redacted] €/ton. For mixed plastic pipe waste that ends up as alternative fuel and where PVC is separated and has an end placement, the price is [redacted] €/ton.
There are 3 examples that could explain these numbers in a more understandable way. The first is that the whole 100 tons of plastic pipe waste gets recycled as mixed waste. The second is that 40% is PE and 60% mixed waste and the third is that 30% is PE and 70% is mixed plastic waste.

1. [redacted] € x 100 ton mixed plastic pipe waste = [redacted] €
2. ([redacted] € x 40 tons of PE) + ([redacted] € x 60 ton mixed plastic pipe waste) = [redacted] € + 40 ton PE granulate
3. ([redacted] € x 30 tons of PE) + ([redacted] € x 70 ton mixed plastic pipe waste) = [redacted] € + 30 ton PE granulate

The prices do not give a realistic picture of what the plastic pipe recycling could cost but they give a direction and a context on what the prices could be.

4.2.2 Stena Recycling Oy

Stena Recycling tells the following about their recycling system. They lay out examples and one of these is that from Joensuu to Pusula it costs [redacted] € to transport 10 tons of plastic pipe waste, the distance is 460 kilometers. Another example says that from Tarvasjoki to Pusula 20 tons of plastic pipe waste costs [redacted] € to transport, the distance is 90 kilometers. Stena Recycling expects that with one freight truck, 10 tons of pipe waste can be moved and this would mean that in the case Tarvasjoki to Pusula the pipe waste has to be moved twice so all in all it is 180 kilometers.

[redacted] € / 460 km = [redacted] €/km
[redacted] € / 180 km = [redacted] €/km

The euro per kilometer prices are quite different but because the distances are quite close to “normal” transportation distances that Stena Recycling drives, the average can be calculated which is (+)/2 = . So the average kilometer cost is approximately euro. To find out the distance that the pipes travel to crushing facilities the average of the distances has to be calculated. This is (90km + 460 km)/2 which equals 275 kilometers.

If the annual amount of plastic pipes that need to be recycled is 100 tons the following things need to be taken into consideration. Stena Recycling has stated that for clean and sorted plastic pipe waste they do not charge anything. For clean mixed plastic waste the charge is euro/ton. For contaminated pipe waste the handling fee is euro/ton. To understand the costs better 2 scenarios are created. In the first 50 tons of clean sorted pipe waste is collected, 45 tons of clean mixed pipe waste and 5 tons of contaminated pipe waste. In the second scenario 90 tons of mixed pipe waste is collected and 10 tons of contaminated pipe waste.

1. If one transportation can take 10 tons of pipe waste, 100 tons = 10 transportations. The average distance is 275 kilometers and the average cost is euro/km.

   Transportation kilometers are 275 km x 10 transportations = 2750 km

   The kilometer cost 2750 km x €/km = €
   Stena Recycling has promised to pay half of the transportation costs from the collecting points to the crushing facilities, so the actual remaining cost is then € /2 = €

   If 50 tons is clean and sorted pipe waste the cost is euro
   If 45 tons is clean and mixed pipe waste the cost is €/ton, 45 ton x €/ton = €
   If 5 tons is contaminated pipe waste the cost is €/ton, 5 ton x €/ton = €

   With this in mind the cost would be

[redacted] € (transportation) + [redacted] € (clean mixed) + [redacted] € (contaminated) = [redacted] €

2. In the second scenario the transportation costs are the same and the distances and plastic pipe waste volumes are the same. However the quality of the waste is different.

   There is no clean and sorted pipe waste
   90 tons is clean and mixed pipe waste that cost [redacted] €/ton, 90 ton x [redacted] €/ton = [redacted] €
   10 tons is contaminated pipe waste the costs [redacted] €/ton, 10 ton x [redacted] €/ton = [redacted] €

   So the final price is

   [redacted] € (transportation) +[redacted] € (clean mixed) + [redacted] € (contaminated) = [redacted] €

These prices are for plastic pipe waste before further processing into raw material or alternative fuel. With these prices the plastic pipe waste has moved from its birthplace to the crushing facility and waits to be crushed. If considering how reliable the cost calculations are, it is important to take into consideration that it might not be completely realistic to transport 10 tons of plastic pipe waste with only one freight truck.

4.2.3 Muovix Oy

Muovix has also told quite openly about their prices that involve recycling plastic materials. According to Muovix own examples the following can be concluded. If there would be 3 tons of pipe waste collected in Vantaa it would cost [redacted] € (supervision and container location cost) + [redacted] € (freight) = [redacted] €. This would be [redacted] €/ton and Muovix has promised that they pay [redacted] €/ton of the plastic pipe recycling costs. This would mean that the Pipe Group would need to pay [redacted] €/ton, all in all [redacted] € for 3 tons. This is the logic behind calculating the cost of the system at Muovix. All pipes are of course not generated close to Vantaa and this is why an average transportation cost needs to be calcu-

lated. HFT Network Oy, which is planning logistics for Muovix, has given an offer containing logistics costs which can be used as a basis for cost average calculations.

[redacted] € (Vantaa) + [redacted] € (Hyvinkää) + [redacted] € (Lahti) + [redacted] € (Tampere) + [redacted] € (Lappeenranta) + [redacted] € (Turku) + [redacted] € (Jyväskylä) + [redacted] € (Kuopio) = [redacted] €/8 locations

Average collecting fee is [redacted]/8 = [redacted] €

8 locations are used for collecting plastic pipe waste. The supervision and container location cost is [redacted] €/container/month. So these costs would all in all be [redacted] € x 12 months x 8 locations = [redacted] €

One container can fit 4 tons of pipe waste. The annual amount of waste is 100 tons and to be able to collect all this 100/4 = 25 times the waste needs to be collected. It is however important to see that the container does not necessarily contain 4 tons of pipe waste every time and this is why a scenario with 3 tons is also calculated, this requires 100/3 = 34 times collecting.

1. So if the average collecting fee is [redacted] € and 25 times is needed for collecting, the logistics costs are [redacted] € x 25 = [redacted] €
   The supervision and container location cost for 8 locations is 10 560 €

   Total costs are [redacted] € + [redacted] € = [redacted] € or [redacted] €/ton

   Muovix pays [redacted] €/ton so the final cost is
   [redacted] – [redacted] = [redacted] €/ton = [redacted] €

2. If again the average collecting fee is [redacted] € and 34 times is needed for collecting, the logistics costs are [redacted] € x 34 = [redacted] €
   The supervision and container location cost for 8 locations is [redacted] €

   Total costs are [redacted] € + [redacted] € = [redacted] € or [redacted] €/ton

Muovix pays [redacted] €/ton so the final cost is
[redacted] – [redacted] = [redacted] €/ton = [redacted] €

These prices are also quite dependent on many factors and thus can not be held as the true costs but as a good direction to what the costs might truly be. It is however good to remember that Muovit pays for plastic pipe waste delivered straight to them ([redacted] €/ton) and that Muovix uses a major part of the collected plastic waste in their own processes. In this way they do not process recycled raw material from other than PVC.

4.3 Price comparison

In order to see the differences in prices they can all be put into one table. These prices are however only showing in what direction costs could develop in different scenarios and should not be considered as an absolute fact. There are many variables that can change and this is why these numbers are highly uncertain.

Table 6 Price comparison between companies to handle plastic pipe collecting for recovery

	Kuusakoski Oy	Stena Recycling Oy	Muovix Oy
First price	[redacted] €	[redacted] €	[redacted] €
Second price	[redacted] € + 30 ton of PE granulate	[redacted] €	[redacted] €
Notifications	Kuusakoski prices are for plastic that are recycled from birthplace all the way to end placement (recycled raw material or incineration)	The Stena Recycling prices are for plastic pipe waste that is recycled from birthplace to the crushing facility, no further processing is involved in the prices	The Muovix prices are for collected plastic pipe waste that is after collection used as a raw material for Muovix own processes. PVC waste is crushed and sold

5 DISCUSSIONS

To find a solution to a plastic pipe recycling related problem, it is important to be able to see the problem from different angles. In plastic pipe recycling there are as many views on the recycling system as there are participants in the system. For some parties it is important just to know where to bring the plastic pipe waste and for others only the cost of the system is important. In the end, the thing that benefits everybody is that there is a functioning system that fulfills its purpose and is smoothly working and credible. To analyze the situation and find solutions for it, the problem needs to be divided into different parts. The most important questions that needs to be answered are the following

1. Where does the plastic pipe waste come from and who would be interested to join a system to recycle the pipes?
2. Where and how would it be suitable to collect the pipes? How would the sorting be made?
3. Who gathers the pipes from the collection points and takes them to a location where they can be processed further?
4. How big amounts of plastic pipes can actually be recycled (collected and further processed) at a reasonable price and who will pay?
5. How and by whom should the plastic pipes be processed further and what is the most cost-efficient method?
6. How do different parties in the system and enterprises that are interested in recycling the pipes get to know the system and use it properly?

There are of course many other questions that need an answer but these are the most crucial ones to be able to put together a simple, working, system for plastic pipe waste recycling. There are also other views on the system. The most important thing that needs to be considered is that the recycling system has to be cost-effective and credible. Cost-effective because the companies that pay for the system do not have limitless amounts of capital to put into it and credible because the whole idea behind this recycling is that the companies want to take care of their products in the end of the products

lifecycle and thus better their image and show that they also appreciate green values and care about where the waste that they generate ends up.

From what can be seen there are a couple of outcomes for this study that could be possible. Some of the outcomes satisfy all the parties and some of the outcomes do not satisfy everybody but they would still offer a cheap and easy way of recycling the plastic pipes and taking care that they do not end up on a landfill. The objective is that everybody would be satisfied but there are many factors that contribute to this. So the priorities that this study is aiming for are

- A cost-effective system (in comparison to the existing one and similar systems abroad)
- A working system that all the parties can easily use and that is credible
- Recycling most of the plastic pipe waste into raw material (second priority is to recycle it as energy recovery). Getting rid of landfilling
- To optimize the collecting and sorting of the plastics both on a local and a national level
- To find more plastic pipe waste streams and increase the volume of plastic pipes that the system processes
- To find reliable and interested partners that feel like the system gives them added value to their functions

5.1 Bases for solutions

The 6 questions presented in the last chapter are used as a base for finding a solution for plastic pipe collecting for recovery in Finland and the priorities (also presented in the earlier chapter) are used as guidelines for the optimal solution.

After researching different systems and companies in the plastic pipe recycling business it is safe to say that most of the existing solutions are quite similar to each other and differ only in smaller details. Most of the companies use some kind of collecting equipment that they empty when it gets full (for example containers), some use collecting vehicles that drive from one location to another, the general idea however is that the pipes

are collected by a company. After the pipes are collected they are delivered to locations where the pipes are sorted according to what plastic they are. This can be done by the companies collecting or a partner company in cooperation. After this the plastic waste is washed, grinded/crushed and/or granulated by some company that has the ability to do this. All the clean plastic is reused and turned into raw material and all the contaminated plastic usually ends up as energy recovery, either incinerated by the collecting and recovering company itself or by some other company that buys the plastic as alternative fuel and incinerates it to get energy out of it. The recycled material is sold further to companies in the plastic production business. In some cases there is only one company (usually a bigger company) that does the process from the beginning to the end and in some cases there can be a separate company for every step on the way to recover plastic pipes. These companies can be situated in the same country or different countries. The ideal situation would be to find a company or a couple of companies that would be interested in incorporating this system also into Finland.

There are some companies that are already well established in Finland, some of them in many countries. For example Kuusakoski Oy, Stena Recycling Oy and L&T are all major contributors in the recycling business in Finland and all private companies. We also have smaller companies that handle recycling processes, for example Muovix Oy, Suomen Käyttömuovi Oy and Ekiplast Oy. On top of these and several other companies, we have the municipal systems with many different companies having versatile logistics systems. So there are a lot of options to start building a plastic pipe collecting for recovery system on. One of the points that were discussed with the plastic pipe producers was that it would be important to have companies working with plastic pipe recycling that have the ability to take care of a big part of the process because it would be easier to cooperate with a few partners in comparison to many partners. In other words, the cooperation with many companies would be harder to organize and much tougher to make contracts that satisfy all the parties. So the minimum requirement is to find a company that would be able to at least process the plastic pipe waste and that would already have a partner to handle logistics. At this point a deal with local municipal waste handlers also became a less important solution for the pipe waste recycling because this would require a contact with too many actors in the business at the same time. It is also a problem that the municipal waste management companies do not operate on a national level.

Speaking of logistics, a matter that limits the results of this research is that the logistics should cover a big enough area nationally and that it would be good to use a transportation system that already exists so that the environmental effect of the pipe collecting would be as low as possible. The volumes of the pipe recycling would also be an important factor so that the system would be credible and serve its cause well enough. Bigger volumes result in increasing logistics costs and since the plastic pipe producers only have limited amounts of capital to invest in the plastic pipe collecting for recovery system, it means that the cost of the system is also a major factor when searching for new cooperators taking care of the plastic pipe waste. It is also taken into consideration that the estimated amount of plastic pipe waste annually is around 5% of the total production volume. In the interview with the plastic pipe producers it was estimated that 70 000 tons of plastic pipes are produced and sold every year in Finland and this would mean that approximately 3 500 tons of plastic pipe waste is generated annually. In theory this would be true but to be realistic the amount of actual plastic pipe waste is probably between 500 tons and 1000 tons, this because bigger size pipes (with a bigger mass) are installed under the ground and in this business less installment waste is generated. The pipes used in construction have a smaller mass but are used in bigger volumes and normally generate about 5% of waste. With this in mind, the amount collected and recovered pipes nowadays (30-40 tons a year), is only 3-6% of the actual amount of pipe waste collected. So optimizing waste streams would also be a highly important subject for this research, without of course affecting too much the cost of the system.

With all the questions, priorities and requirements as a background, I decided as my first option to find companies that could take care of the entire pipe recycling system. As a second option small companies that have well established partnerships were very interesting. So companies that would be of high interest for this research are

- Kuusakoski Oy
- Stena Recycling Oy
- L&T
- Muovix Oy

As my third option I saw that making the recycling system more effective would probably solve many of the problems that the system experiences today, this includes also searching for new waste streams and increasing the amount of waste, in other words, contacting water management facilities and construction companies. During the research some foreign companies also contacted me. They were mainly interested in PVC waste so the possibility of shipping further the PVC waste abroad was also taken into consideration. The idea to incorporate the plastic pipe collecting into municipal systems was not considered because it was not preferred by the plastic pipe producing companies to work with too many partners and because municipal plastic waste ends up almost entirely as energy recovery.

5.2 Different views on possible solutions, answers to the 6 questions

The first question is about where the plastic waste comes from and who would be interested to recycle it. The plastic waste comes from the plastic pipe producers. Some of the waste is treated as production and industrial waste and recycled internally in the companies. The amount of post-consumer waste is estimated to be around 500-1000 tons annually and this waste comes from companies that either distribute the pipes or use the pipes in end applications. So most of the pipe waste is generated on construction yards, wholesales yards and sewage and water management facilities. In this research the material that is interesting is plastic pipes that have a low level of contamination so basically pipes that never end up in their final use and are taken to landfills, pipes for clean water distribution, cutoff pipes, left over pieces after fitting or installing and other clean non-contaminated plastic pipes. Other requirements are that the pipes are PE, PP, PVC or PEX and preferably produced by KWH Pipe, Uponor or Pipelife Finland. As seen in field studies, there are a lot of pipes that could be recycled in the current pipe recycling system for example on construction yards (Skanska) and in water management facilities (HSY). From the field studies it is apparent that there are many waste streams that could be incorporated in the existing plastic pipe recycling system. In this way the question of increasing the volume of plastic pipe waste could be tackled.

In interviews many companies have stated already that they are very interested in taking over the plastic pipe recycling system from L&T that is the main operator now. Many companies have also shown advantages over L&T, for example Kuusakoski that concentrates more on material recycling than L&T and Muovix that could be able to use many of the plastic pipes as raw material for their own processes. Stena Recycling would also be interested in recycling the plastic pipes but they do not have much plastics recycling in Finland yet though they are an established recycling company and they are widely spread throughout Finland and many other countries.

The second questions is about how the pipes should be collected and how sorting should be done. The current system is according to interviews with L&T and Onninen working very poorly right now. The wholesales yards feel according to both the interview with Onninen and the questionnaire that they are becoming like landfills where all kinds of waste can be delivered. This seems to be a development in an undesirable direction. There are several possibilities to collect the pipes in another way. For example Kuusakoski and Stena Recycling that are spread throughout the country could receive plastic pipe waste at any of their facilities and recycling yards around Finland. It could also be possible to start cooperating with construction companies and have containers on bigger construction yards. Some companies would be ready to store the pipes for some time before they would be picked up by a circulating truck. Muovix suggested that the pipes could be collected on waste collection stations that are situated around Finland. I think that a combination of all these solutions would be the best and this needs to be decided on meetings with the company that will handle the plastic pipe recycling. To tackle the sorting issue, it would probably be the most effective way to collect all different pipes in containers and sort them afterwards. If the containers would consist of several sections and the pipes should be sorted on collecting location it would put too much responsibility on the companies wanting to bring the pipes to recycling points. I think that the system attracts more people to recycle the easier it is to use. Some companies however suggested that the sorting should be done at the collecting location, these companies told that this would optimize both cost and logistics. Another problem is the size of the pipes and them fitting inside the container. It would be good to be able to reduce the size of at least the biggest pipes so that there would fit more pipes inside the container. This could be solved with a grinding machine or a saw attached to the container but it is

good to remember that this would be expensive so a cheaper solution would be preferred.

The third question is about gathering the pipes from the collecting locations. Kuusakoski have their own logistics system that takes care of this matter and smaller companies like Muovix has a partner (HFT Network) that could take care of the logistics. Stena Recycling handles everything else in recycling, except logistic. They have outsourced this. Because the logistics is the most expensive part of plastic pipe recycling, as we have seen in the example of Sweden, and because Finland is such a sparsely populated country, it is important that the company that takes over the plastic pipe recycling already has a well established logistics system. In this way the volumes of pipe waste can easily be increased without the costs increasing too much. For example a company that needs to distribute all the plastic pipes to one location in Finland has to pay much more logistics costs than a company that is able to distribute the pipes to several destinations in Finland. In this question the bigger companies are more suitable partners than a smaller company, except if the smaller company can somehow cut down the logistics costs with good partnerships.

The fourth question is about the costs of the system. Logistics costs are quite similar to all companies driving material from one location to another, the more kilometers you drive the more it will cost. The decisive thing is how a company can incorporate the plastic pipe recycling into already existing functions in the company or how they can find a trustworthy partner to handle the logistics. As seen in the case of L&T, the system costs close to 25 000 euro annually and 40 000 tons of plastic pipes are collected and further processed. This means an average cost of 625 euro/ton. From the cost calculation we can see that any of the companies that were compared could match easily the L&T system and in every case be much more cost-effective. Any of the companies that would have interest in continuing with the plastic pipe recycling could offer a cheaper price than the current system. They could also do this with a higher volume of pipes recycled. One thing however that needs to be considered is that the calculations of the three companies do not include the same services. For example Kuusakoski prices include plastic recycling from birthplace to recycled granulate, Stena Recycling prices include pipe recycling from birthplace to crushing facility and Muovix prices include

the collecting and then the materials end up in Muovix own processes. During this research I was also contacted by PVC recyclers from Holland, a company called Van Werven Groep. They offered [redacted] euro/ton for PVC waste delivered to them to Holland. This however is not a very cost-effective deal for Finnish companies and thus was not taken into further consideration.

The fifth question handles further processing possibilities for the plastic pipes. Muovix for example is able to use PE, PP and PEX in their own processes. They recycle PVC and sell that further. The bigger companies are able to recycle into new raw material all the different plastics. In both cases the requirement is that the plastic waste that is processed further has to be pure and without contamination from foreign substances or materials. Kuusakoski has partners in several countries that are able to further process all kinds of plastics but to send the plastic abroad is expensive so it would be best to collect material that can be processed with the equipment found in Finland. L&T is the only company that is able to wash, crush, extrude and granulate plastic waste into recycled raw material but for them it is not cost-efficient to do this if the waste volumes are not closer to 10 000 tons annually. This is why mainly packaging material is processed in this way nowadays. With the plastic waste being only less than 1000 tons annually this does not seem like an option. L&T, Kuusakoski and Muovix are all experienced in the field of further processing plastic pipes so I consider at least these companies as able to further process plastic pipe waste in Finland. Stena Recycling is a very experienced recycler so they would most probably be able to handle any waste stream. Especially for Kuusakoski and Muovix it is highly important to use the pipe waste as a new raw material. L&T is not able to recycle the pipe waste into raw material as long as the volumes are as low as they are right now.

Questions number six is about making the system more effective. It can be seen from L&T and Onninen interviews and the questionnaire that the current system has some major flaws in it. It would be highly important, no matter what company takes over the plastic pipe recycling, that the system is seen through starting from the basics in the system. For example the location of the collecting container, the looks of the container, the information on the container and the people responsible for the container should be optimized so that the system works in its most fundamental parts. It is also highly impor-

tant to inform the different parties in the recycling system and all companies and people in the plastic pipe industry about the possibility to recycle plastic pipes. The system should be simple and clear and the advantages that the companies get when they return plastic pipe waste should be stated clearly. This means basically that the companies that return plastic pipe residue can better their image and they can avoid landfill fees by returning the plastic pipe waste for free to collecting locations. It would also be very important to make a small marketing campaign about the new system and in the upcoming years follow up the system and make sure that it still works and that all parties still are well informed about how the system works. Partnerships should also be constantly created to increase the volumes of the pipe waste. For example Kuusakoski would be ready to use their entire educative and informative system that they have to make the system known. Muovix would like to cooperate with the Pipe Group and SUM to spread the word of the system.

5.3 Comparisons between selected companies

The four companies investigated further, function all quite differently in a geographical scale. This is illustrated in the figures 23-26. The following things are worth considering when looking at the figure.

The situation as it is now is described in figure 23. The black squares are all places where plastic pipe waste is collected, in practice wholesales yards. The green squares are waste handling facilities where the plastic pipes are mainly processed further to alternative fuel used in energy recovery processes. L&T operates this system.

The Stena Recycling establishments are seen in figure 24. Black squares are collecting facilities and the green square is their crushing facility that is mainly used for crushing copper cables. It can however be adjusted to crush also different plastic waste streams. Stena Recycling has outsourced their logistics and they also cover nationally a quite large area.

In figure 25 the Kuusakoski system can be seen. The black squares are all Kuusakoski collecting facilities. The green squares are Kuusakoski own crushing facility and their partners Suomen Käyttömuovi and Ekiplast crushing and granulating facilities. Kuusakoski operates its own logistics on the entire area and covers the biggest area nationally of all the companies compared. Kuusakoski also has most crushing facilities in use because of well established partnerships.

In figure 26 the suggestion given by Muovix is illustrated. The black squares are collecting locations for the plastic pipes that would in this case be waste stations where all kinds of waste are gathered. The green square is the Muovix facility in Riihimäki where further processing into Muovix own profiles and crushing is done. The red squares are locations from where collecting could be done but needs to be evaluated because it is very expensive. The ring describes the maximum distance from the green square from where Muovix can collect waste pipes without any extra cost for the organizing part, in this case the Pipe Group of Muoviteollisuus Ry.

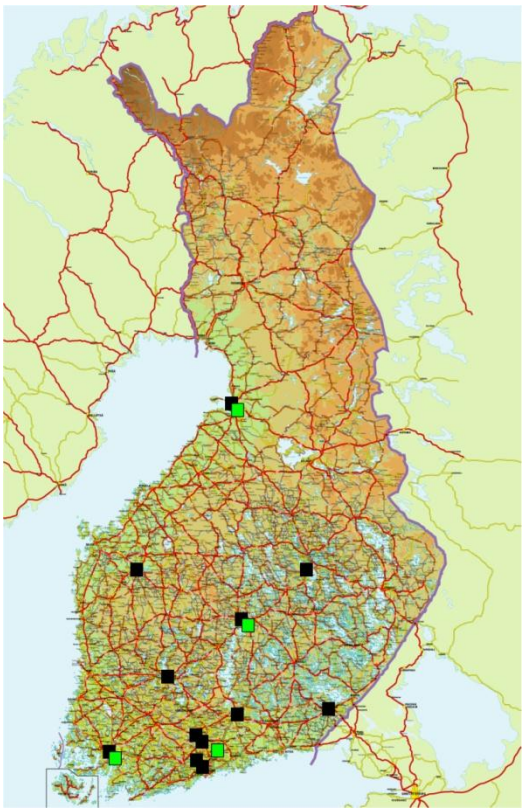


Figure 23 The recycling system of L&T

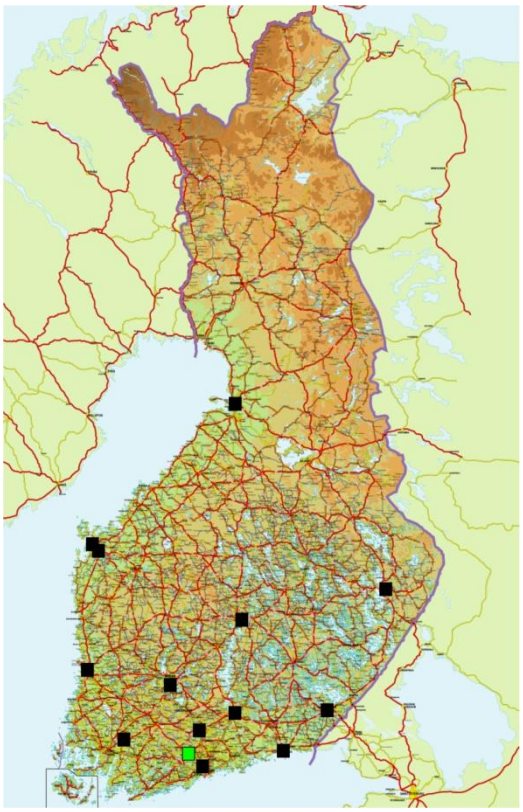


Figure 24 The recycling system of Stena Recycling

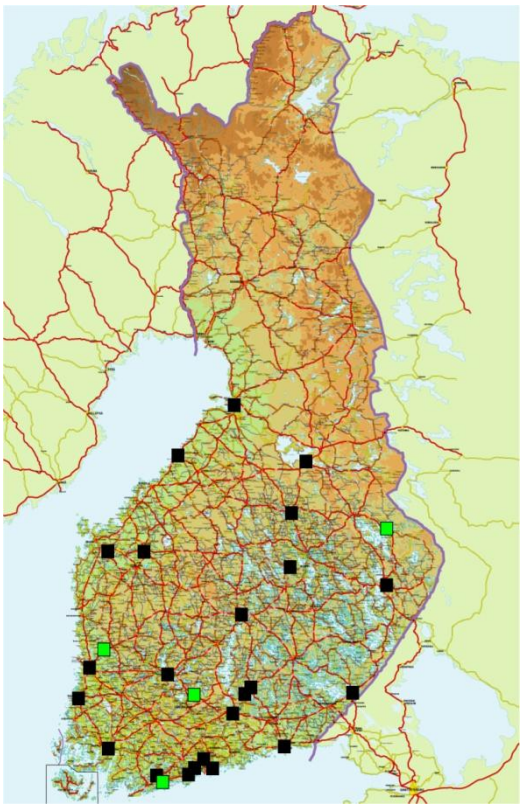


Figure 25 The recycling system of Kuusakoski

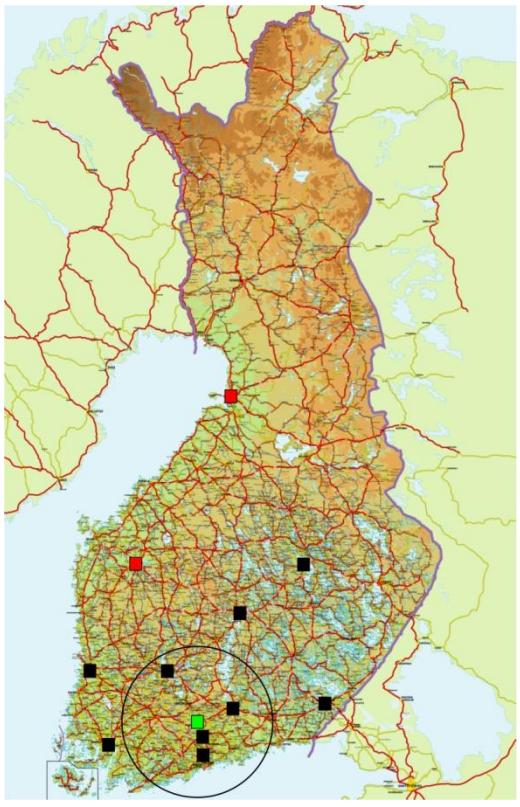


Figure 26 The recycling system of Muovix

Comparing these different figures with each other it can be seen that different companies have different advantages. Kuusakoski for example has the biggest system and is spread throughout the country. Stena Recycling is also very well spread through Finland but they only have one crushing facility which means that they would need to deliver plastic pipe waste from great distances to only one location which is expensive. They can however incorporate the plastic pipe recycling into their metal recycling and use the already outsourced logistics in an effective way to move around the plastic pipe waste. Muovix is a smaller company and has thus decided to tackle a smaller area. In a way this is smart because a large majority of the plastic pipe waste is generated in the southern parts of Finland. The bad thing on the other hand is that the system would not be a national system but in the end this might not matter because the most important things are that the system is credible and cost-effective. So if great enough volumes can be collected from this area then it is sufficient. The existing system operated by L&T is quite good in a geographical sense and the delivery locations are situated wisely in comparison to collecting locations.

The figures are not only about the geographical location, they are also in a high grade about the meaning of the squares. Though the squares are of the same color on the different figures it does not mean that they are the same thing. For example the green squares in the L&T figure are facilities that process the plastic waste into alternative fuel for incineration. L&T does not recycle the waste into material unless big enough volumes are reached. The green square in the Muovix figure is a crushing facility like the one in the Stena Recycling figure. Here the plastic pipes are crushed and possibly granulated into recycled raw-material and it means that the waste that is delivered to these locations should be clean and with only very small contaminations like sand or dust. In the Kuusakoski figure the southernmost green square is a crushing facility that is owned by Kuusakoski. The three green squares up north from the left are the Suomen Käyttömuovi crushing and granulating facility and Ekiplast crushing and granulating facilities. So Kuusakoski has a major possibility to recycle the waste as material and both Muovix and Stena Recycling have the ability to do this too but in a smaller scale and more locally. L&T has the only facility in Finland that washes, crushes and granulates waste plastics but this is not on the map because volumes of over 10 000 tons are

needed so that it would be cost-effective to establish a material recycling line for a certain waste stream in this facility.

So advantages and disadvantages for the chosen companies are the following ones

- L&T has the most advanced recycling facility in Finland and is an established recycler. L&T is however not very interested in plastic pipe recycling with small volumes (under 1000 tons annually), does not have material recycling as their biggest business and main purpose, prefers to create alternative fuel
- Kuusakoski Oy is the biggest material recycling company in Finland, has national logistics and many partners specialized in recycling, has a big network to use for marketing, is able to provide pipe producers with recycled raw material, has well established partnerships, is able to receive pipe waste for free to any facility, and has good references from different recycling systems. The disadvantages are the high costs of a big company, the pipe waste recycling might not be a big enough waste stream to get the full interest of the company and Kuusakoski has high hopes of maximizing the waste streams to get bigger volumes which might be a cost issue in the future
- Stena Recycling Oy is the second biggest recycling company in Finland, they have a large outsourced logistics system, they only drive full loads and they have good references. Disadvantages are that they only have one crushing facility and no bigger partnerships in Finland, they are quite new to plastics recycling and they charge for mixed plastic waste delivered to them
- Muovix Oy is a small company specialized in plastic recycling, is able to use the major part of plastic pipe waste in their own processes, does not require huge volumes of pipe waste, focuses on a small enough area where most of the waste is generated, pays for pure waste delivered to them and is ready to contribute to the costs of the logistics. Disadvantages are that there is no national coverage, they only have one crushing facility and they are able to produce raw material for pipe producers only from PVC

6 CONCLUSIONS

Collecting plastic pipes for recovery combines many different branches of industry. The most important one is logistics, but to be able to further process the plastic material and benefit from it, as the valuable material it is, both material technology and processing technology is needed. But it does not end there, trade (buying and selling) is also a hugely important factor and without solid continuous waste streams and customers that need recycled raw material, there is no recycling business.

The three questions that this research has as an objective to answer have been considered and the following things can be concluded from this research:

1. "To find out what other existing systems there are that could collect and recycle plastic pipes and could the plastic pipe collecting join one of those systems"

   Several different companies that already have existing recycling systems have been found and many of these companies are interested in incorporating the plastic pipe collecting for recovery into their own businesses. Examples of companies are Muovix Oy (a smaller company interested in plastic waste streams), Kuusakoski Oy (the biggest recycling company in Finland), Stena Recycling Oy (the second biggest recycling company in Finland) and L&T (a recycling multitasker). The objective of the Pipe Group is to create a business for the company that takes care of the plastic pipe collecting for recovery and themselves only participate in marketing costs, this however requires that the pipe waste volumes need to be increased.

2. "To find out would it be more cost-effective to use another waste management system than the current one to collect and recycle plastic pipes"

   The current system is very expensive and ineffective and other companies are able to offer much cheaper and more effective systems. Some companies even have widely spread logistics systems that they are able to use and in this way

minimize costs. An important thing that needs to be taken into consideration is the relation between costs and volumes, the bigger the volumes are the bigger the costs usually are. The amount of plastic waste collected however needs to be high enough so that the system is credible.

3. "To find out would it be worth developing the existing system, and in this case, how to bind the actors in the system to use it as it should be used, in a correct and effective way"

   It would absolutely be worth developing and optimizing the current system but since the different parties nowadays do not want to continue with the plastic pipe collecting for recovery, the main aim is to develop and optimize the system with a new cooperative company. To be able to do this in a correct and effective way, a lot of resources are going to be put into marketing the new system and informing different parties in the system about recycling the plastic pipes. The Pipe Group could function in this case as a consultant because they already know how the pipes can be collected. In the case of starting a new system many things should be taken into consideration, for example where the pipe waste should be collected (wholesales yards, waste stations, private company yards?), how the collecting devices should look like (containers, bags, boxes, information stickers?), the purity of the waste and sorting, the persons responsible for the containers, birthplace sorting or sorting after transportation and the marketing and making the system known in the plastic pipe business.

Furthermore some suggestion have been made so that the Pipe Group and the Environmental Group can have a solid base for their decision on how to continue with the plastic pipe collection for recovery. In the following sub-chapters are the suggestions that are based on research in this work. Some of the suggestions are less probable to happen but are still scenarios that could be taken into consideration if better options do not work.

The three most potential companies to handle the plastic pipe collecting for recovery are Kuusakoski Oy, Stena Recycling Oy and Muovix Oy. L&T could continue but they

have stated that it is not in their highest interest to continue. To incorporate the system into municipal waste systems and turn everything into alternative fuel would be a waste of expensive raw material but still a last resort instead of the pipe waste ending up on landfills.

6.1 Suggestion number one

L&T continues, only the system will be made better and more effective. The biggest problem with the existing system is that it is hugely ineffective. So the plan would be to move the containers to better locations (from the wholesales yards to waste stations) and see that for every container there would be a person responsible. Only clean plastic pipe waste can be dropped off at collection points and this is followed up by the waste station personnel. The L&T logistics will empty the containers when they get a notice from the waste station that they are full. The plastic pipe waste will be shipped to L&T crushing facilities where it will be crushed with other energy recovery waste and transformed into alternative fuel that will be sold further. Homogeneous waste deliveries could be sold further to other companies like Muovix Oy or Ekiplast Oy for material recycling. A marketing campaign will be launched and awareness spread through the plastic piping business. Cooperation with construction companies and water management facilities could be established to increase waste volumes.

6.2 Suggestion number two

Muovix Oy takes over the whole system with its partners. Muovix will buy the containers from the Pipe Group and strategically place them according to their suggested plan on waste stations around southern Finland. They will take care of the logistics together with their partner HFT Network Oy. Plastic pipe waste is delivered to Riihimäki to Muovix crushing and production facility and here the pipes will be sorted according to material. Polyolefins like PE, PP and PEX will be used in Muovix profile production, the first two as raw material and the third as a filler. The PVC will be crushed and sold further to the pipe producers or some other company. Muovix and the Pipe Group will work together to market the system and to spread awareness of plastic pipe recycling. New sources for pipe waste will be found and incorporated in this system. Muovix is

able to start the recycling with a very short notice (within a week from the decision) and in practice they are already investigating how to recycle the pipes in the most effective manner.

6.3 Suggestion number three

Kuusakoski Oy takes over the system. Kuusakoski incorporates the plastic pipe recycling into their existing logistics and collecting system so that the pipe waste will be collected at all Kuusakoski facilities in Finland. In the beginning the main focus of the collecting would be on the areas of the greater Capital Region and on Pirkanmaa. When the system has grown and when it is up and running it will be widened to a national level. The pipe waste in the most logistically inconvenient parts of Finland could be collected with campaigns once or twice a year. Collecting is made so that companies that want to get rid of their waste can without a fee drop off the plastic pipe waste at Kuusakoski facilities. Here Kuusakoski will sort them and take them to crushing and granulating facilities. This will be done in a logistically smart way so that the pipe waste is taken to the closest crushing facility. Here the clean waste is crushed and turned into raw material that is sold to the pipe producers or to companies that are not in a competitive role to these. Recycled raw material can also be shipped abroad. The contaminated waste will be turned into alternative fuel. A wide information and marketing campaign will be launched in the beginning so that all parties know how the system works and know why they benefit from using the system. Within one month the system would be ready to start running.

6.4 Suggestion number four

Stena Recycling takes over the system. Stena starts to collect plastic pipe waste to all their facilities. Streams from wholesalers to installment are tackled so that all clean pipe waste will be recycled. Stena Recycling takes deliveries with clean and homogeneous pipe waste for free and for mixed pipe waste a sorting fee has to be paid by the company that delivers the waste or wants to get rid of the waste. The pipe waste will be sorted at collecting locations. When storage is getting full the pipe waste will be taken to Pusula where crushing is done. The recycled raw material can be sold further, either abroad or

to plastic producing companies that want to buy it, also the pipe producers. A massive marketing campaign would be launched to create awareness and to inform all parties about how the system works. Stena Recycling could start the plastic pipe collecting for recovery within two weeks.

6.5 Suggestion number five

Incorporate into municipal waste collecting or energy recovery. The easiest way to get rid of the plastic pipe waste would be to incorporate it into energy recovery collection. Many private companies do this in Finland but also the municipalities gather energy recovery waste. In this way the pipe waste would end up as alternative fuel for the industry in Finland. This is a very cheap solution, however not a very smart one. The main objectives of this research are to find a credible and cost-effective solution and though this would be a cost-effective one, it would not be a very credible one and would not support the green image that the companies are trying to build for them.

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8 APPENDICES

8.1 Questionnaire about plastic pipe recycling

Question 1.) What area of business do you represent?			
	Answer	Amount	Percentage
1.	Municipality/City	6	8 %
2.	Water management facility	3	4 %
3.	Wholesales/Retailer	61	81 %
4.	Excavation company	4	5 %
5.	Other installment company	0	0 %
6.	Other	1	1 %
	Total	75	100 %
Question 2.) How much plastic pipe waste is generated annually from your actions?			
	Answer	Amount	Percentage
1.	Under 1m³	25	33 %
2.	1-10m³	26	35 %
3.	10-20m³	15	20 %
4.	over 20 m³	8	11 %
5.	Other way to express amount	1	1 %
	Total	75	100 %
Question 3.) What does the plastic pipe waste consist of in your field of business?			
	Answers	Amount	Percentage
1.	Spare parts and leftovers	12	16 %
2.	Aged parts or useless products	6	8 %
3.	Broken products	42	57 %
4.	Old water and sewage pipes	11	15 %
5.	Other	3	4 %
	Total	74	100 %
Question 4.)What do you do with plastic pipe waste nowadays?			
	Answers	Amount	Percentage
1.	With energy recovery	14	19 %
2.	With normal waste	14	19 %
3.	We ship to a plastics company for reuse	15	20 %

4.	We ship to containers on wholesales yards	20	27 %
5.	We leave it in the ground	0	0 %
6.	We have it in our storage	3	4 %
7.	Other	8	11 %
	Total	74	100 %

Question 5.) What would be the easiest way for you to get rid of plastic pipe waste?

	Answers	Amount	Percentage
1.	Deliver to a collecting point	25	34 %
2.	Deliver to a local waste recieving central	3	4 %
3.	Deliver a bigger amount to a plastics company for reuse	10	14 %
4.	To store plastic pipe waste that would be picked up once a year	25	34 %
5.	Put in energy recovery or wastebins	9	12 %
6.	Other	2	3 %
	Total	74	100 %

Ideas to develop the system

- A circulating collection truck one or two times a year would be awesome
- I have never seen emptying of the container on the wholesales yard, nobody knows where to deliver the material. The container came on the yard years ago
- On the wholesales yard a collecting point and when needed when full, emptying has to be ordered
- Appropriate bins/containers for different material collecting
- The collecting containers need to big so that longer pipes can fit, The unloading of the pipes should be effortless. Not just a small hole in the container side.
- Our customers could be interested in bringing their pipe waste to collecting bins if there would be any. This system is lacking from wholesales yards. Wood is already collected in a smart way but plastics go to the energy recovery bin
- I do not see it as a good idea that wholesalers would handle leftovers from construction yards and such. The wholesales yards would become like landfills
- The pipe waste should be accepted without a fee on landfills and this would encourage companies to recycle pipe waste. Plastic pipes are anyways very light and do not cause big costs when handled with other waste
- We are ready to sort different plastic types and store them for some time so that they can be taken to collection points
- Crushing equipment would be good to reduce the size of the pipes so more would fit on the containers

8.2 Interview with L&T

1.9.2011 at the L&T Kerava office, present Rasmus Pinomaa from Arcada - University of Applied Sciences, Secretary General Aulis Nikkola from Muoviteollisuus Ry and Unit Manager Ville Vainio from L&T.

What does L&T recycle?

L&T is a major contributor in the recycling business in Finland. L&T can handle almost any waste problem and a lot of waste is reprocessed to energy recovery that is sold further to factories that use it as a fuel to get energy for their processes. Sorted plastics can also be processed into granulates that can be used as a raw material in the plastic industry. L&T aims to recover as much as possible of the existing raw materials in waste.

How do you see the plastic pipe recycling right now?

The plastic pipe recycling is somewhat problematic for L&T. The volumes are quite low, it is not profitable to gather the plastic pipes and it is not possible to recycle the pipes to new raw material because the quality of the waste pipes in the containers is varying too much. The recycling of plastic pipes is basically charity work for now.

Why is the gathering of the plastic pipes not cost-effective?

The containers are filled with up to 6m long plastic pipes that can sometimes be very thick. These do not fill the container evenly and air gaps are left in between. This results in a lot of unused space in the containers and effects logistical costs negatively. If the pipes could be cut into smaller pieces, more material would fit in the containers. With the system right now, an average container with recycled plastic pipe weighs only 2-3 tons when it arrives at our processing facility. The containers are over 24m³ so the space is not used very well. It would be more cost-effective right now to put the pipes in the energy recovery container instead that crushes the material at the gathering location and contains much more material which makes logistics more worthwhile.

So the distances to get the pipes are quite long, the volumes of the pipe waste are too small and logistics is not profitable. Above all of this the storage space that these pipes require on the recycling facility is very big and thus very expensive in comparison to materials that can be compressed into smaller spaces.

So if L&T was to give up the plastic pipe recycling and no further contract would be made about this, what would happen with the containers?

L&T does not have any use for the containers, they are basically scrap material. So if Suomen Uusiomuovi Oy would be interested in buying them to be able to continue with the plastic pipe recycling, they could be sold for a scrap price.

Is there anything else that L&T would like to point out?

So that plastic pipes could be turned into new raw material, the volumes would need to be up to 10 000 tons a year so that it would be profitable to put up an own recycling line for the pipes. If the volumes stay as low as now (30-40 tons a year), the smartest thing is to crush these plastic pipes into energy recovery. This is also why it is very ineffective to have both an energy recovery container and a plastic pipe waste container on the same wholesales yard.

8.3 Interview with Muovix Oy

1.9.2011 at Muovix production and recycling facility in Riihimäki, present Rasmus Pinomaa from Arcada - University of Applied Sciences, Secretary General Aulis Nikkola from Muoviteollisuus Ry and General Manager Mikko Koivuniemi from Muovix.

What is Muovix?

Muovix is a company that makes profiles by extruding from different waste plastics. Muovix also crushes other plastic materials that they do not use in their own processes and recycles them to new raw material. With other companies such as HFT, Muovix has a substantial gathering network for waste plastics. The company uses mainly different PE and PP for their own products. Muovix extruding profiles are used in various applications, for example as fences, wall modules and floor panels.

Would Muovix be interested in gathering plastic pipe waste that consists out of PE, PP, PVC and PEX?

Both PE and PP can be used in Muovix own products and PVC can easily be crushed and converted into recycled plastic raw material. As long as the waste material is somewhat clean and without contaminations it can be both recycled and used in the processes. PEX can possibly also be used in Muovix own processes, it is under research if it could be used for example as a filler. So, Muovix would be interested in the plastic pipe recycling.

How would Muovix handle the actual recycling?

Muovix is cooperating with HFT Network Oy that offers environmental services. They could handle the logistics and gathering of the waste plastic pipes and other cooperating companies could chop the pipes to smaller pieces. Muovix would themselves need to sort the plastics but all this is a matter of organizing. Muovix is right now having a pilot project in Kuopio where they have “plastic gathering circles” where they collect plastic

waste from local shopping centers. A similar system could maybe be implemented in the plastic pipe recycling.

If the containers that are now used for gathering plastic pipes would be available, would Muovix have an interest in them?

If the cost for the containers is high then the subject needs to be discussed but if the price is right Muovix and its partners would like to get the containers and manage them.

Would Muovix also be interested in plastic pipe waste from water management facilities and construction yards?

Water and sewage treatment plants gather plastic waste that they sort by themselves. It would probably be a good source of raw material. Construction yards need to be looked into if there is any possibility to gather the plastic pipe waste from there and how it could be done.

Other things that need to be considered?

There would be at least 10 containers and the biggest possible gathering area would have to be covered with these. The most important areas would of course be population centers in southern Finland. If the gathering costs around 100€/ton Muovix would be ready to do the gathering for free, the actual processing price for one hour would be around 35€/hour. Crushed HDPE costs around 200€/ton so by gathering the plastic pipe waste the aim would be to get the material cheaper than when buying it. Muovix will come up with an offer of the complete recycling system during September month and there explain how they would handle the pipe recycling and what it would cost.

8.4 Interview with Skanska Oy

7.9.2011 at Skanska construction yard in Herttoniemi, Helsinki. Present Rasmus Pinomaa from Arcada - University of Applied Sciences, Secretary General Aulis Nikkola from Muoviteollisuus Ry and Environmental Executive Johanna Pakarinen from Skanska. Both e-mail interview and on location interview combined.

How big is this construction yard and how do you gather waste plastics at the location?

The construction site is average size, 776 m², and there are 2 buildings with 4 and 5 stories and every level has 3-4 apartments. There are plastic recycling bins on every level of the buildings and these are emptied to a bigger recycling point at the construction site where the plastic waste is sorted. Even very precise sorting of different plastics could be possible at Skanska construction sites but the only problem is that nobody is interested in picking up and further processing the plastic waste from the construction yard.

How is plastic recycling working on construction yards (sub-contractors opinion)?

On this site it works very well, actually we haven't seen it work this well anywhere else. On many constructions huge amounts of plastic waste is thrown away because it is cheaper that way. When something is built the deals are usually contracts rather than people working on a monthly salary. This means that time is money and there is no time to make precise measurements, so for example it is cheaper to cut a too big piece of plastic pipe and fit it afterwards instead of starting to measure precisely. This contributes to a lot of waste. We have seen at bigger construction sites complete sewage systems thrown away and shipped to a landfill because they have been ordering too much material to the sites.

How much plastic waste do you have on the site right now?

We have had since construction began in January 2011 at least four big-bags (850 liters) of mainly plastic pipe waste, 3 big dustbins full with plastic waste pipes and four 240

liter bags with plugs. Most of the material is PVC but sometimes also pipes of other materials are used. At this site some of the pipe work has been done with copper and steel that usually is done with plastic, so the amount of waste plastic pipes is not optimal. Subcontractors very often handle their own recycling of spare material and other institutions have been interested in waste materials like for example Suomen Settlementti säätiö that runs a flea market for second hand construction material. The recycling on construction sites is just starting to grow and it is still very ineffective. This is also why there are no statistics on exactly how much plastic pipe waste is generated on construction sites. Many subcontractors however estimate that 2-5% of plastic pipes end up as waste material.

8.5 Meeting with Oy KWH Pipe Ab, Pipelife Finland Oy and Uponor Suomi Oy

8.9.2011 at Muoviteollisuus Ry office in Helsinki, present Rasmus Pinomaa from Arcada - University of Applied Sciences, Secretary General Aulis Nikkola and Karl-Johan Ström from Muoviteollisuus Ry, Product Manager Tomi Lempinen from Oy KWH Pipe Ab, Application Manager Elsa Launiainen from Uponor Suomi Oy and Project Manager Seppo Kuusela from Pipelife Finland Oy.

What do you want from this study and how do want it to be presented?

The outcome of the research on how to recycle plastic pipe waste in Finland should have at least a couple of clear suggestions that the companies that pay for the system could choose from. This means that cost calculations and proper estimations of everything that needs to be done should be considered. It would also be very important to think about how the new system needs to be marketed and how different people involved in plastic pipe recycling would easily start using the new system. So the implementation of the system is also important. It would also be interesting to know a price for recycled plastic raw material.

What do you think of the current system?

The current system does not work and it costs the companies paying for it 25 000 euro every year. The volumes of plastic pipe waste have been disappointingly low especially the last couple of years and it would be important also to find out how the volumes could be higher, as long as that does not mean an increase in cost. In the beginning it was estimated that 100 tons would be the annual amount of waste, now only 30-40 tons are gathered every year.

What is the most important thing for you in plastic pipe recycling?

The image of the company is the most important thing. It is a modern trend that companies have some kind of lifecycle management and this is why it is important also for a

company to take care of the products that they produce in the end of the products life-cycle and see that the cycle becomes full in an environmentally friendly way. If the companies take care of their plastic pipe waste their image gets much better. The other thing is that it would be important to have a credible and meaningful recycling system. Every year approximately 70 000 tons of plastic pipes are produced and sold in Finland, which is a little bit less than 10% of the total plastic production. It would be important to gather as much as possible of the waste that this production amount generates but to do it in a cost-effective way.

8.6 Invitation to meeting with the Environmental Group

MUOVITEOLLISUUS RY
Finnish Plastics Industries Federation

KOKOUS 40

Putkijaosto/ 2.9.2011 A Nikkola

KOKOUSKUTSU

YMPÄRISTÖRYHMÄN KOKOUS 40

Aika: Torstai 8.9.2011 klo 14.00

Paikka: Muoviteollisuus ry, Helsinki
Eteläranta 10, 7 krs, Plastiikki

Esillä: **1**. Kokouksen avaus ja läsnäolijoiden esittäytyminen

2. Tarkistetaan ja hyväksytään edellisen kokouksen 9.8.2011 pöytäkirja nr. 39

3. Uuden selvitystyön vetäjän Rasmus Pinomaan tehtävän läpikäynti ja keskustelu siitä tehtävän tavoitteesta, aikataulusta ja raportoinnista, ottaen huomioon, että Pinomaa tekee samalla opinnäytetyötä

4. Muoviputkien keräilyn selvitystyön tilanne mm:
- Tämänhetkisen tilanteen lyhyt esittely
- todetaan mitä Pinomaa on tehnyt projektin suhteen
- AN:n raportti käynnistä L&T:llä ja Muovixilla 1.9.2011
- sovitaan miten selvityksen tekoa jatketaan
- muita selvitystyön edetessä esiin nousseita seikkoja
-

5. Muut mahdolliset asiat

6. Seuraava kokous?

Ystävällisin terveisin

Aulis Nikkola

8.7 Interview with Onninen Oy

9.9.2011 short e-mail interview with Quality Manager Ari Nybäck from Onninen Oy.

How do wholesalers feel about the current plastic pipe recycling?

At Onninen they feel that the biggest problems are that the containers are used very little. In some of Onninen's wholesales yards there has been so much plastic pipe waste that L&T has randomly came and picked them up but mostly the containers do not even get filled during a year. Both their customers and their own employees know very little of this plastic pipe recycling and since the persons in charge of it change quite rapidly because of internal personnel changes, it is very hard to pass the information further how the recycling should be handled. Companies cooperating with Onninen have been active and made sure that plastic waste has not been a problem on their yards. From Onninen's point of view, the plastic pipe recycling does not create any added value to them, nor to their customers.

8.8 Figures and statistics from NPG concerning plastic pipe recycling in Sweden during year 2010

Due to secrecy could not be attached

8.9 E-mail from the Dutch Association for the Plastic Pipe Industry

The Dutch plastic pipe waste recovery & recycle system (BIS) is already operational for 20 years. It was the first operational plastics recovery & recycle system in the Netherlands.

Reasons for the members of the Dutch association for the plastic pipe industry BureauLeiding to found BIS in 1991 were:

- pressure from the authorities on PVC could be partly avoided by preventing PVC to end up in landfill or incineration
- a recovery & recycling system could decrease dependency on virgin raw materials, and
- a recovery & recycling system would be a boost for the image of the Dutch plastic pipe industry.

The fact that after 20 years BIS is still operational means that it has been and still is a success. It's role however has changed. When BIS started it was the only way to get ride of plastic pipe waste that should not end up in landfill or incineration. When on a European level Recovinyl was introduced, a market for plastic pipe waste was created. Please note that the Dutch BIS system collects plastic pipes from PVC, PE and PP, and that Recovinyl is only relevant for PVC. But since the larger part of the Dutch plastic pipe waste is PVC, the impact of Recovinyl in the Netherlands was very important. Today we see that approx. 80% of all recovered and recycled plastic pipe waste is being collected by other parties than BIS.

This is a situation which the members of BureauLeiding appreciate very much. It has never been their intention to make BIS a business of its own. BIS was founded to create awareness and to enable plastic pipe waste collection. That the market has taken over is a positive development. BureauLeiding members in the mean time get more plastic pipe recyclate from the market than from BIS.

Some figures: Over 2010 experts have identified a volume of approx. 12.000 tonnes of PVC pipe waste in the Netherlands, of which approx. 4.500 tonnes directly via waste collectors, incl. BIS, and approx. 7.500 tonnes as part of other waste streams (a/o building & demolition waste).

The total amount of collected PE pipe waste is uncertain, since this is not being collected separately by parties other than BIS. The BIS volume for PE pipe waste in 2010 was approx. 450 tonnes, which obviously is only a (small?) part of the total volume. Via BIS (Pipe Collection System) we have 85 collection points for used pipes, operated together with Wavin and Dyka in the Dutch Pipe Association. We collect 2.000 T p.a.(quote Paul Ummels)

Please note that these figures deal with plastic pipe waste that is fit for recycling. Obviously there will be more plastic pipe waste, but this will be either unfit to recycle quality wise, or it is too expensive to separate it from the general waste stream. The Dutch plastic pipe waste recovery system BIS is fully owned by the industry, and there are no tax advantages or other financial advantages from the authorities involved. However, investing in BIS still is worthwhile for the members of BureauLeiding, because the authorities recognise this as an important contribution from the industry for a sustainable society. I have attached a presentation from 2006 (in English) which describes the general principles of BIS, and which gives some insight in structure and costs.

I hope this information is of some help to you. Please contact me if any questions remain.

Kind regards,

Roger

Roger Loop

Director

BureauLeiding*, *informatiebureau kunststof leidingsystemen

www.bureauleiding.nl | roger.loop@bureauleiding.nl | +31 70 444 0 650

PO Box 152, 2260 AD Leidschendam, The Netherlands | Office address: Loire 150, 2491 AK The Hague

Member of NRK (, de koepel voor de Nederlandse Rubber- en Kunststofindustrie), www.nrk.nl

8.10 Interview with Kuusakoski Oy

29.9.2011 at Lasihytti 4, Kuusakoski Oy, kauklahti recycling service facility in Espoo, present Rasmus Pinomaa from Arcada - University of Applied Sciences and Project Manager Kalevi Koivumäki from Kuusakoski Oy

What is Kuusakoski Oy and what does it have to do with plastics recycling?

Kuusakoski Oy is Finland biggest recycling company and the second biggest privately owned enterprise in Finland. Kuusakoski is active in 11 countries. We process over 20 000 tons of plastic each year of which 90% is recycled as material and 10% as energy recovery. We have our own energy fuel processing facility and we are going to build another one in the upcoming years so that our total capacity for making fuel for incineration plants will be 350 000 tons annually. Kuusakoski has been increasing the amount of plastic recycling every year and nowadays it is a part of our business. For example end of life vehicles (ELV) recycling and WEEE recycling are done by Kuusakoski.

What is the philosophy of Kuusakoski?

We want to recycle as much waste as possible so that it can be reused. Priority number one is always material recycling and priority number two is energy recovery. We function in many countries and have many different cooperative companies so that we are able to fulfill these objectives.

Would Kuusakoski be interested in recycling plastic pipe waste in Finland?

We would most certainly be interested in the plastic pipe recycling. We could offer a nationwide logistics system and we have collecting locations and recycling facilities all over Finland. We also have partnerships already with construction companies and water management facilities from where we collect pipe waste so collecting more pipe waste would suit our business very well.

Would you be interested in the containers that are nowadays used in the pipe recycling?

We would be interested in the containers and could buy them for a nominal price. However the requirement is that they need to be in proper condition and they need to be able to be operated with a hook, not pulled by a cable on the trucks. We would also prefer open top containers but this is something that needs to be investigated what container could work the best in this application.

How do you see the plastic pipe recycling in Finland in the future?

We would like to participate in it but the requirements are that the persons and companies involved in plastic pipe recycling would have a positive attitude to developing the system and with partnerships increase the volumes of the pipe waste. In the beginning smaller areas could be covered and then step by step the system could expand. For example pirkanmaa and the capitol region could be good starting points. It would be possible to deliver pipe waste to all Kuusakoski facilities and the waste could be delivered for free by anyone in the business and in this way landfill fees could be avoided. From the estimate of 3500 tons of plastic pipe waste annually, it would be good to recover at least 1000 tons. Kuusakoski would like to establish a long time partnership in plastic pipe recycling and build up a known brand around it. Kuusakoski would also be ready to pass out the information about how to recycle pipes and educate different parties in this matter. The time will show but Kuusakoski will probably make investments into plastic recycling facilities in the future or maybe build one of their own.

8.11 Interview with Suomen Uusiomuovi Oy

11.9.2011 at Eteläranta 10 Helsinki, Muoviteollisuus Ry office, present Rasmus Pinomaa from Arcada - University of Applied Sciences and Managing Director Vesa Kärhä from Suomen Uusiomuovi Oy

What is Suomen Uusiomuovi Oy?

It is a non-profit limited liability company owned by 44 companies and organizations in Finland that aims on creating and running recycling systems for plastic materials so that they can be recovered. The main objective is to recycle into raw-material.

How do you see recycling in Finland? What are the positive and negative sides?

Electricity and labor are expensive cost factors in Finland and the image of the recycling business is considered "dirty" and challenging which means that people do not appreciate it as much as other businesses. The bureaucracy in recycling is also made very challenging and it is often contradictive. It is rather complicated to be successful in the recycling business. It is a two way business all the time where you have to find reliable waste streams and at the same time find enough paying customers who need the reprocessed waste as a raw material for their processes. Without both ends fixed there is no recycling business and even with them a lot of troubles can still occur, for example the stable quality of the incoming feedstock and how the re-processed product stream suits the needs of the customer. Many businesses also tend to be quite conservative and prejudiced towards recycled material if they are accustomed to certain standards based on virgin materials.

Do you believe that the new waste legislation will change how we are recycling plastics?

The new waste legislation that is now given out and will come into force in May 2012 handles more the municipal waste and does not have so much to do with business to business recycling. The companies still decide themselves where their waste ends up.

There are however many interesting questions that need to be tackled in the upcoming years, for example how much can municipalities outsource their waste management and what will happen with landfills that are planned already for a certain capacity but are not yet running in a full scale. Here we could maybe even see a temporary increase in the use of landfills. Recycling municipal plastic waste is a whole other story. In comparison to waste streams from the industry that are controlled and somewhat clean, the municipal plastic waste consists of a big amount of different plastics that have a much higher level of contamination. The nominal annual capacity of the state of the art incinerators in Finland will increase to over one million tons annually in the upcoming 3 years. This means that most of the municipal plastic waste will most probably be recovered for energy purposes as is done in many other Nordic countries already.

Should the plastic pipe recycling volumes be increased and thus increase the cost of the system?

The driving force of the plastic pipe recycling system right now is more related to public relations and customer service than the value or need of the material itself. It is important for companies to be able to take care of the whole life-cycle of their products but the collection and recycling of disposed products and parts are quite complicated and expensive tasks.

What company do you think would be most suitable to recycle the plastic pipes?

I would rather see a smaller scale, entrepreneur type, company in Finland take care of the plastic pipe recycling. We have already tried a bigger company in this system and it has not worked out the way we expected. The scale is just not right with big ones. I am willing to trust more in Muovix Oy, Suomen Käyttömuovi Oy, Ekiplast Oy, Uusiomateriaalit Recycling Oy or another similar company. Another way would be to incorporate the system into an existing system that collects and recycles something else, like Encore Oy who recycles paper. There are also other interesting companies like Ekokem that is probably going to build a recycling facility next to their new waste disposal facility and SITA that has a quite new plastic sorting facility in Rotterdam. Swerec in Sweden could

also be a possibility since they are sponsored by the Recovinyl program and could thus take PVC waste from Finland.

8.12 Interview with Stena Recycling Oy

19.10.2011 at Lehdokkitie 2 B, Vantaa, Pipelife Finland salesoffice, present Rasmus Pinomaa from Arcada - University of Applied Sciences and Customer Manager Lauri Rantalainen from Stena Recycling Oy

What is Stena Recycling Oy and what does it have to do with plastics recycling?

Stena Recycling Oy is a Swedish family company that is involved in three different businesses, shipping, oil-refining and recycling. The turnover of the company is 7 billion euro and approximately half of the turnover is from the recycling business. In the beginning Stena Recycling Oy was mainly focused on recycling metals but starting five years ago also other materials were taken into the recycling system, amongst these also plastics. In Finland we are only doing recycling and the turnover is 100 million euro. We employ 100 persons in Finland.

How does your plastic recycling work?

We are a quite new to plastic recycling in Finland and our annual volumes are hundreds of tons of plastic waste, might be today closer to a thousand tons. Our main objective is to help our customers to avoid sending waste to landfills and we try to recycle everything to new material purposes. If this is not possible the second option is energy recovery. We have a crushing facility in Pusula that is originally intended for copper cable crushing but it can be easily modified to crush plastics. We also have a energy recovery crushing facility in Nastola. Our working method is that we gather a lot of material from all over Finland and when we have enough of one material, we drive it through the crushing lineup and sell the crushed material further as raw material, in most cases abroad. Our logistics in Finland are outsourced.

Would Stena Recycling Oy be interested in recycling plastic pipe waste in Finland and how would you handle this?

Stena Recycling Oy would be interested in the plastic pipe recycling. There would be however some requirements that would need to be fulfilled or at least worked on so that the recycling would function properly. One thing would be that the sorting needs to be taken care of at the collecting locations. All Stena Recycling facilities around Finland could be used as collecting points and it would be important also to gather the plastic pipe waste from construction yards and other waste streams. The ideology would be to tackle all different steps where the plastic pipes travel so first wholesalers then installment companies and then the construction yards where the installment is done. The pipes could be collected straight from these for example with bags so that different material pipes would be in different bags. Then when these would be returned to Stena Recycling collecting points, the sorting would be already taken care of. We could accept all readily sorted deliveries to our facilities and if mixed plastic pipe waste is delivered a sorting fee would need to be paid. Another thing is the purity of the waste, to be able to use further the pipes and crush them into recycled raw material they would need to have a low level of contamination. The pipes would be gathered at the different facilities and when enough pipe waste has piled up then they would be moved further to the crushing facility. No half empty freights are made.

Would you be able to deliver raw material to the plastic pipe producers?

We are able to crush the plastic if the level of contamination is low enough and sell further the crushed plastic waste back to the same customer. The color of the recyclate can however not be altered, all the colors are mixed. Because of the higher amounts of PE, PVC and PP these would probably be the easiest ones to recycle as raw material. PEX would most probably end up as energy recovery.